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(54) **CRIMPLESS ELECTRICAL CONNECTORS**

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H01R 4/30 (2006.01)
H01R 4/32 (2006.01)
H01R 13/05 (2006.01)

(52) **U.S. Cl.**
CPC ***H01R 4/305*** (2013.01); ***H01R 4/302*** (2013.01); ***H01R 4/32*** (2013.01); ***H01R 13/052*** (2013.01)

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See application file for complete search history.

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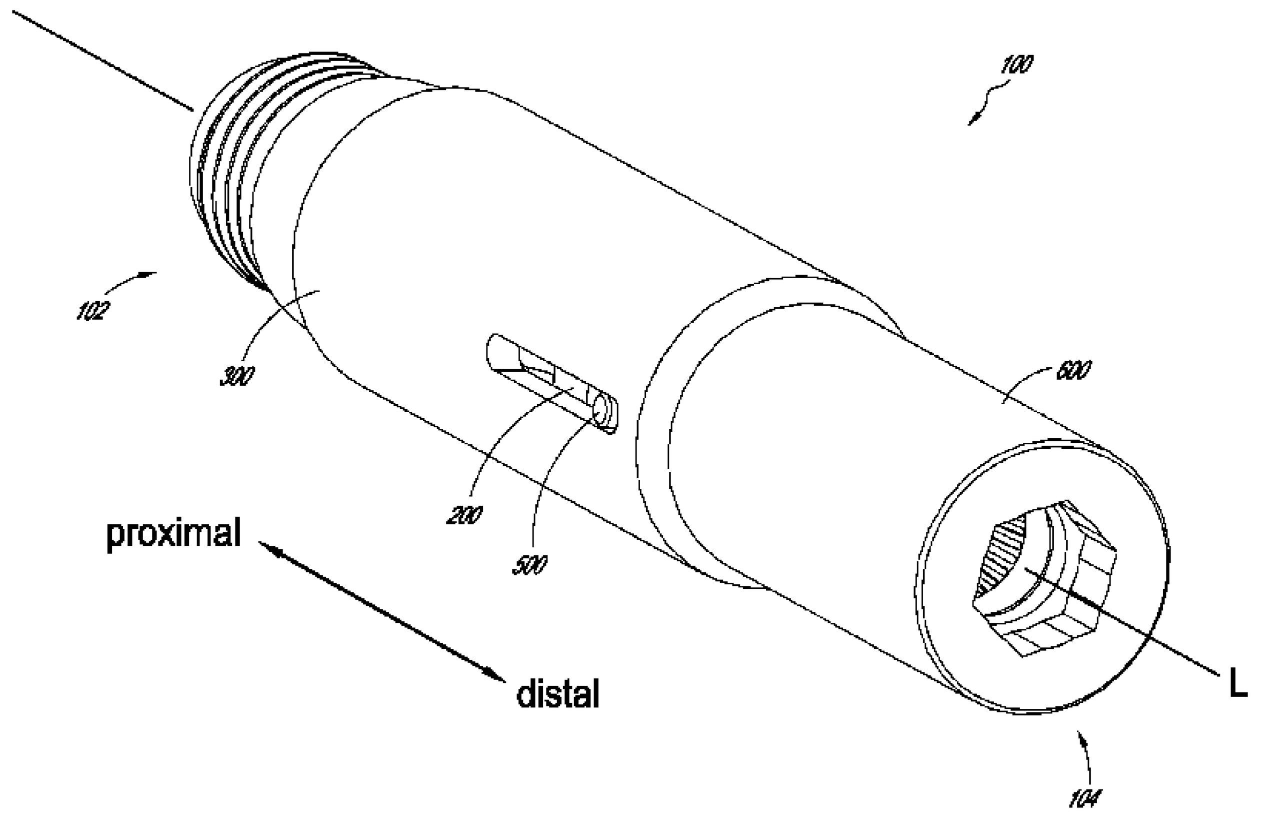
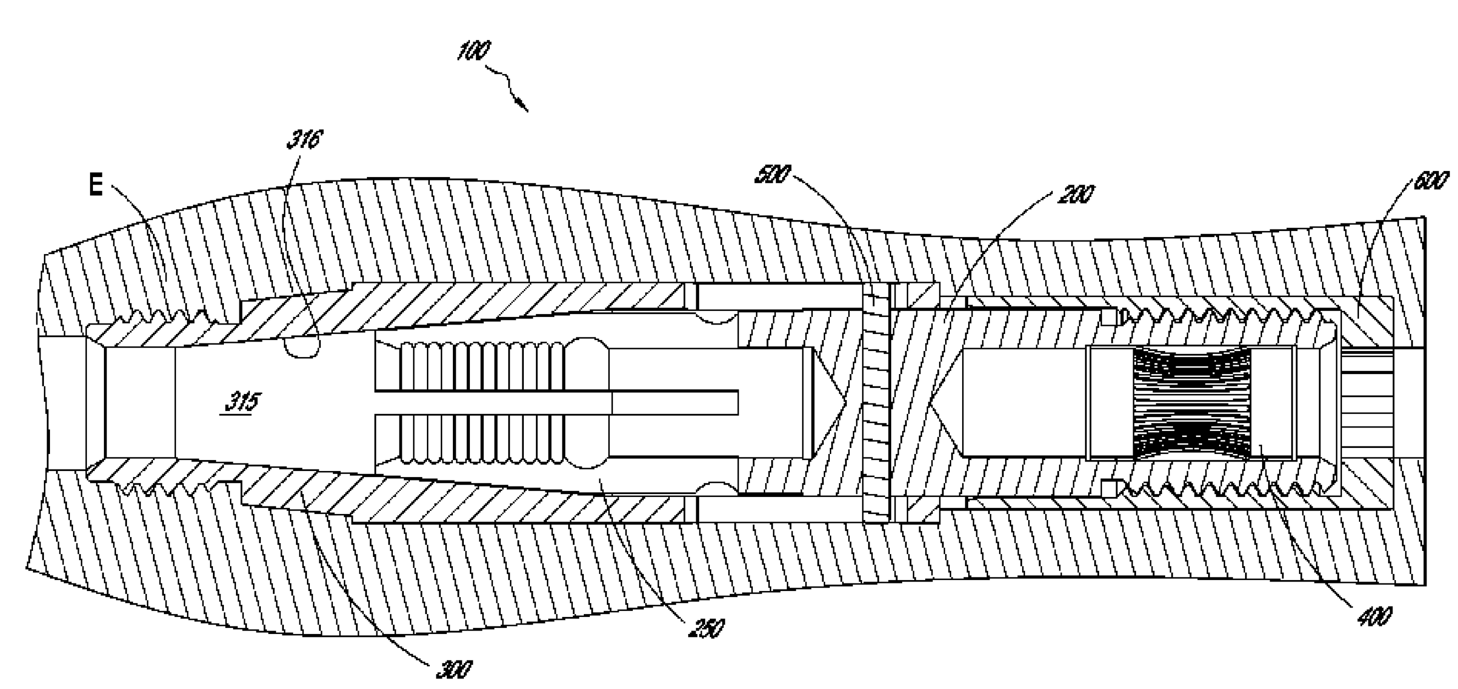
(57) **ABSTRACT**

Various crimpless electrical connector assemblies are disclosed. The crimpless connector can include a crimpless contact configured to join two electrical conductors. A portion of the crimpless contact can be received in an outer housing that comprises a tapered lumen. The crimpless contact can be coupled to an activation unit, such as with a threaded connection. Rotation of the activation unit can cause the crimpless contact to translate within the outer housing and the tines to be compressed against the first conductor, thereby physically securing the first conductor in the crimpless connector.

24 Claims, 11 Drawing Sheets





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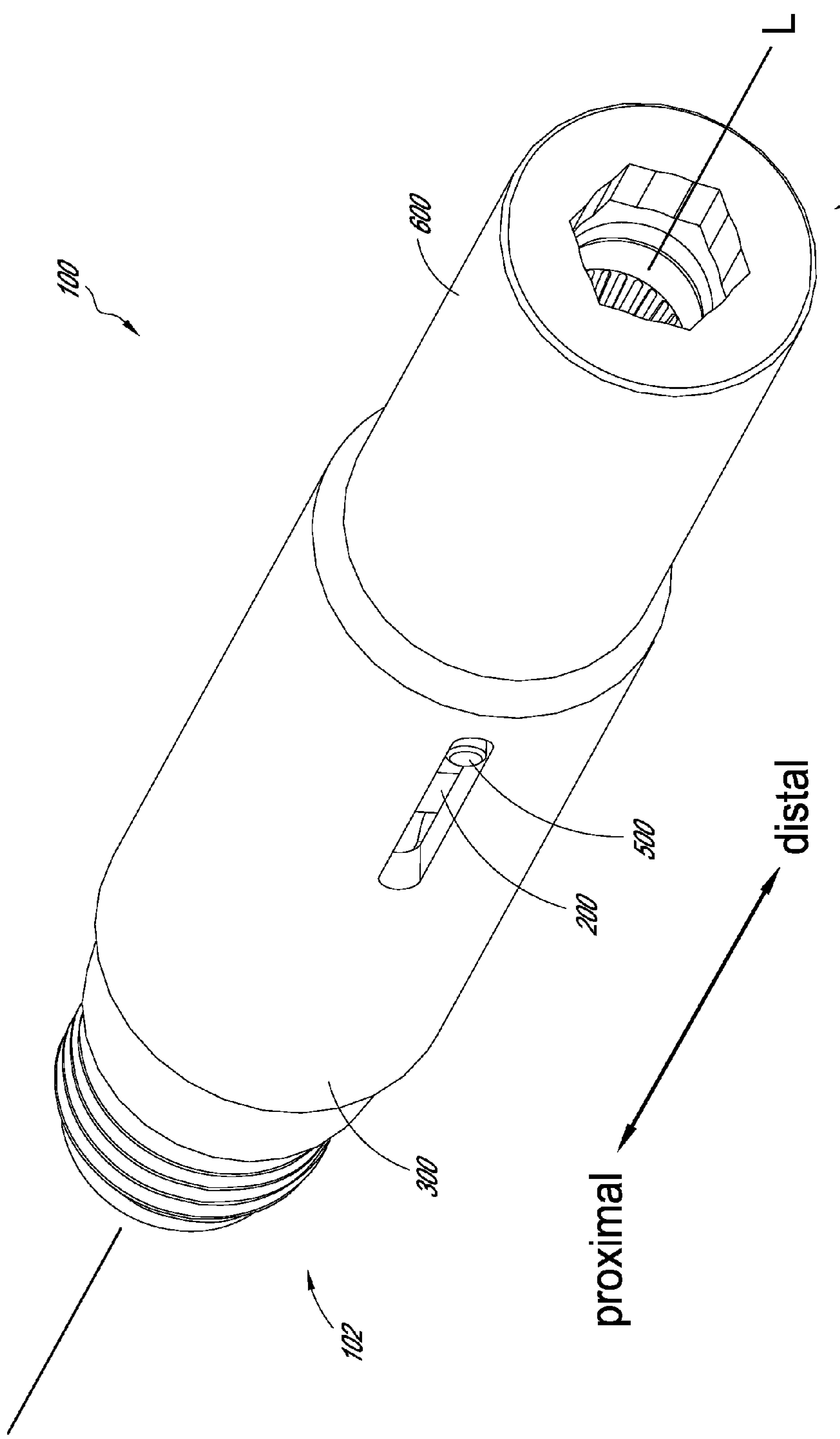

FIG. 1A

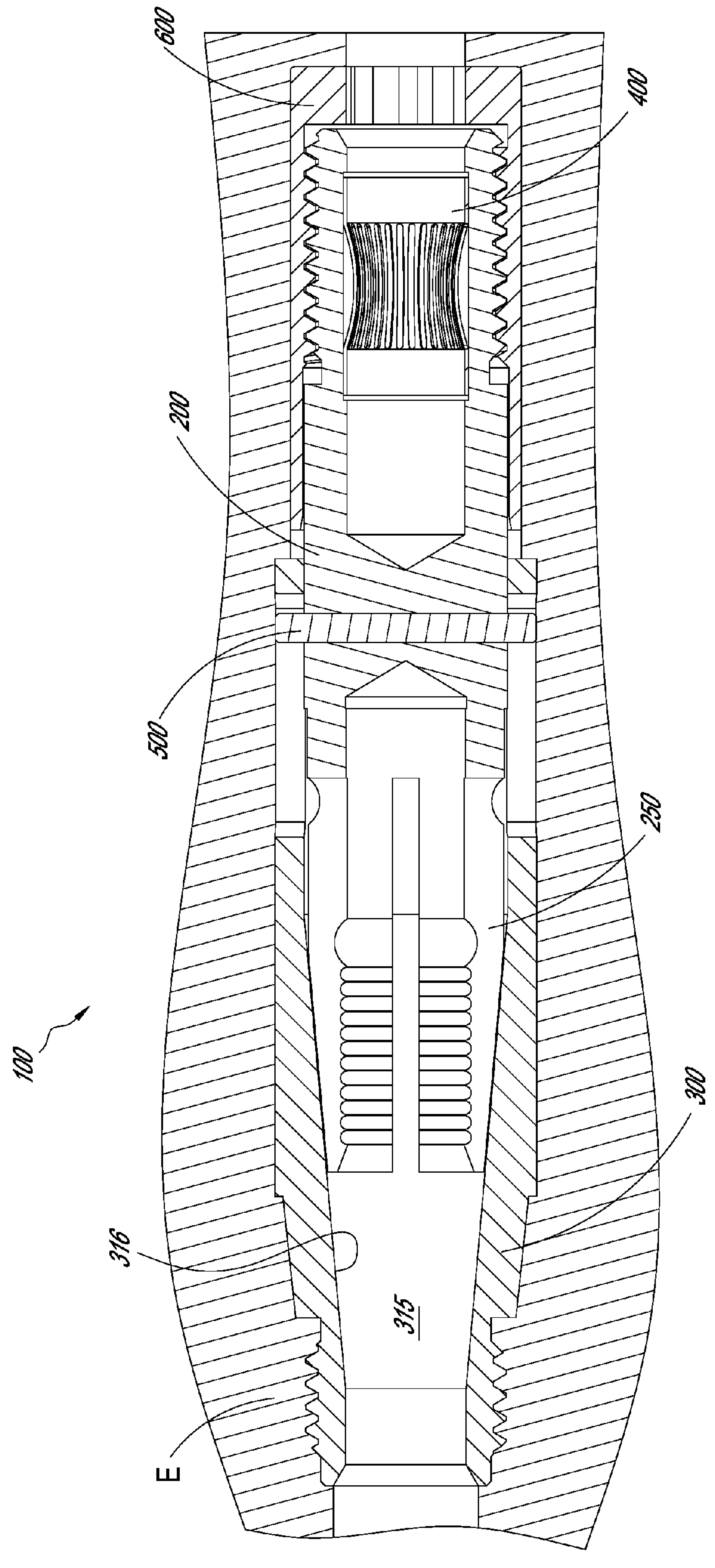

FIG. 1B

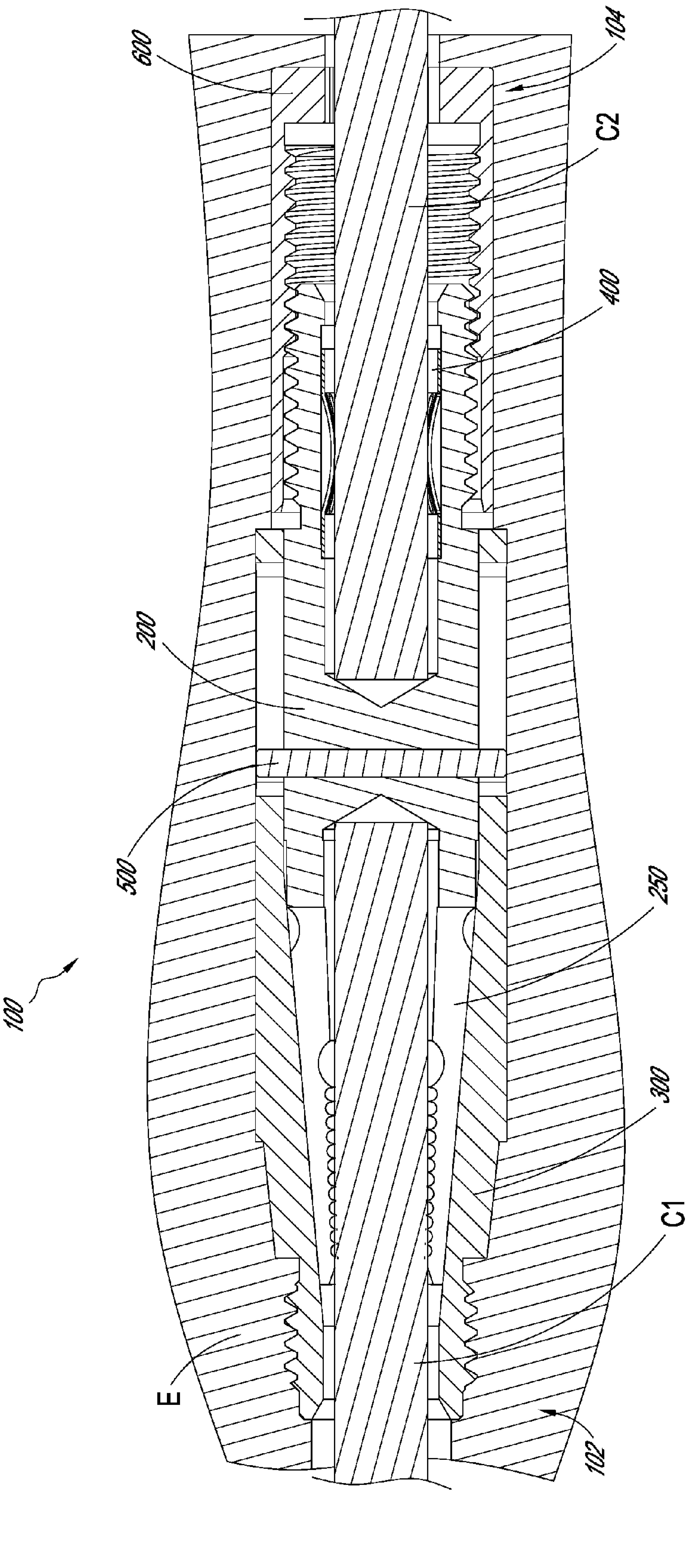

FIG. 1C

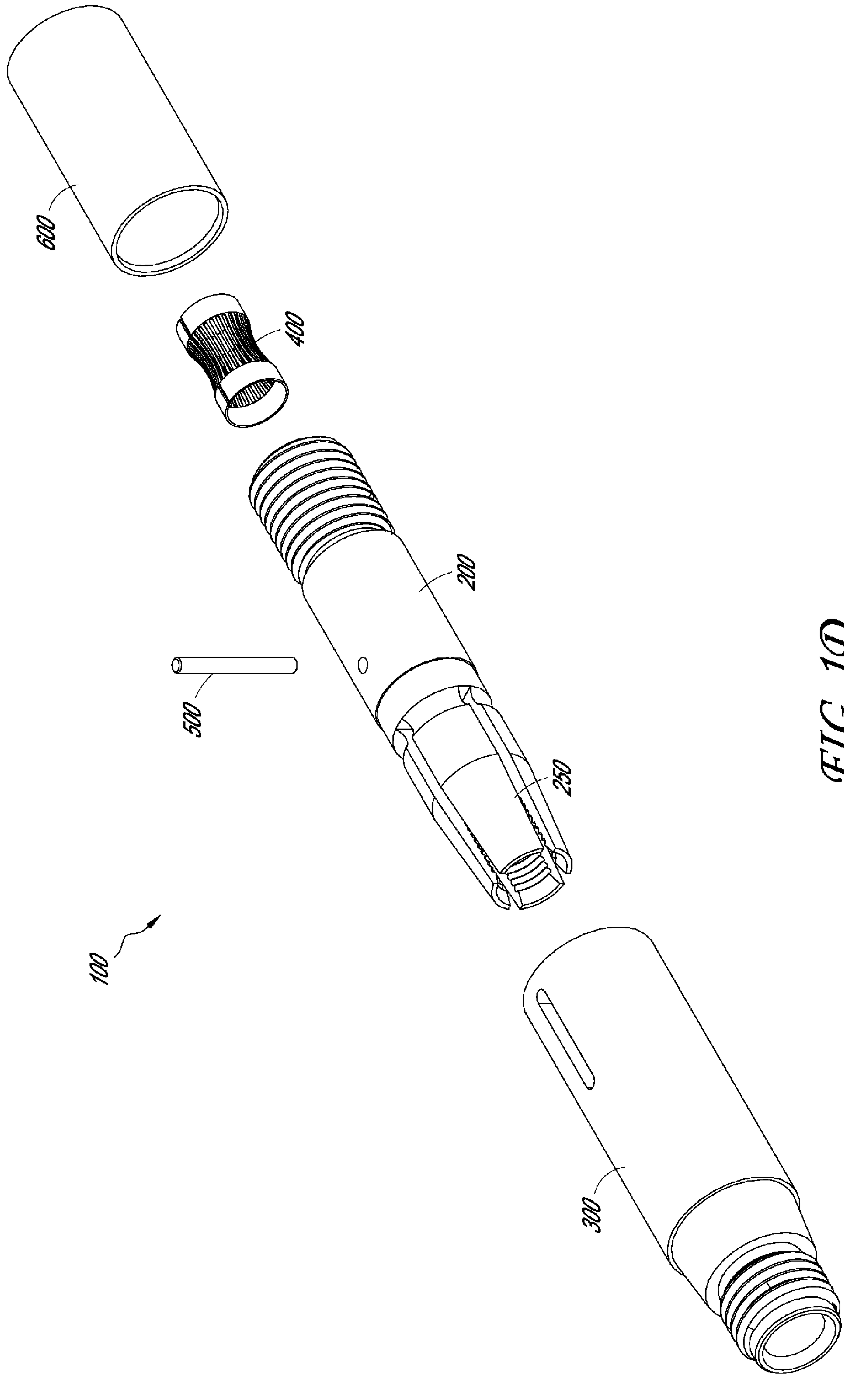

FIG. 1D

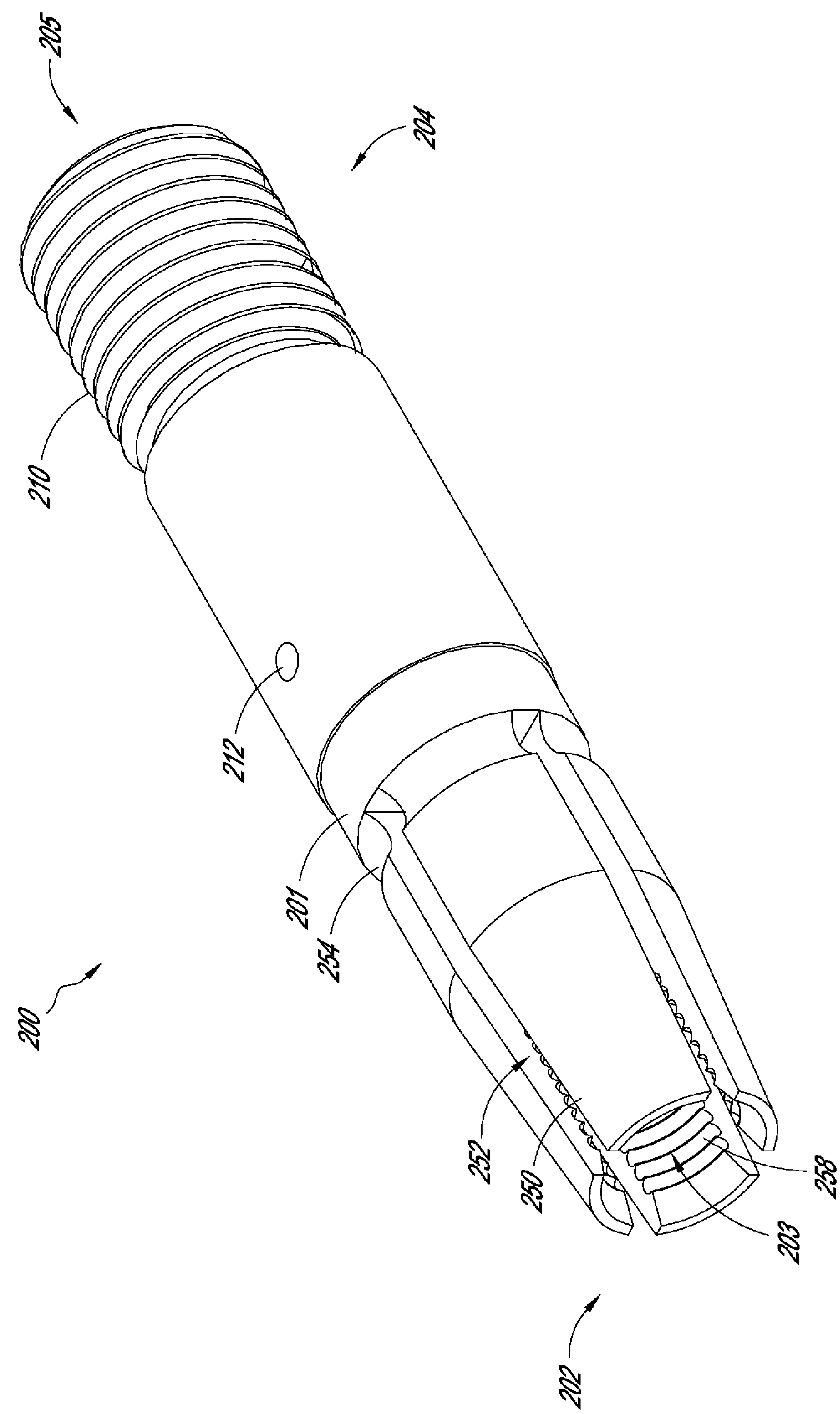

FIG. 2A

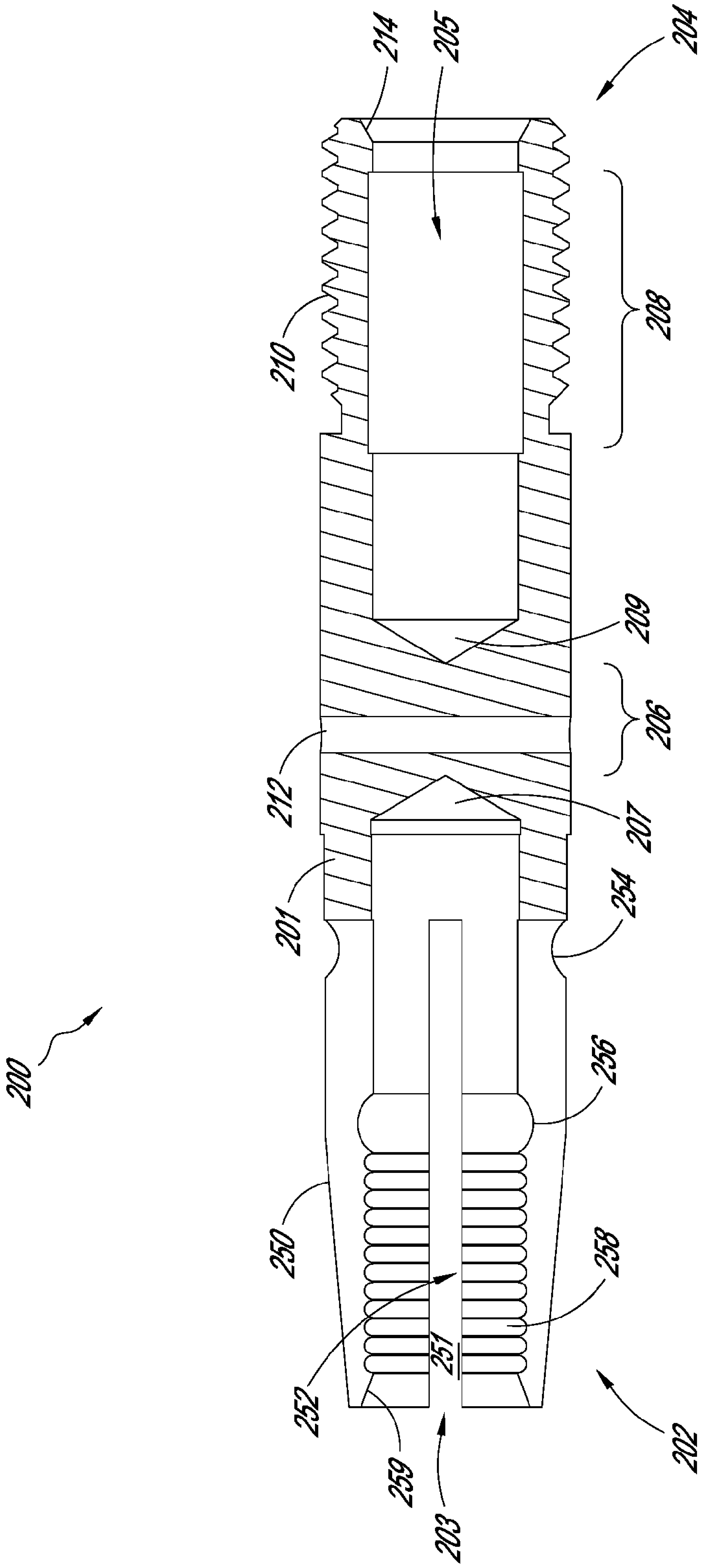
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FIG. 2B

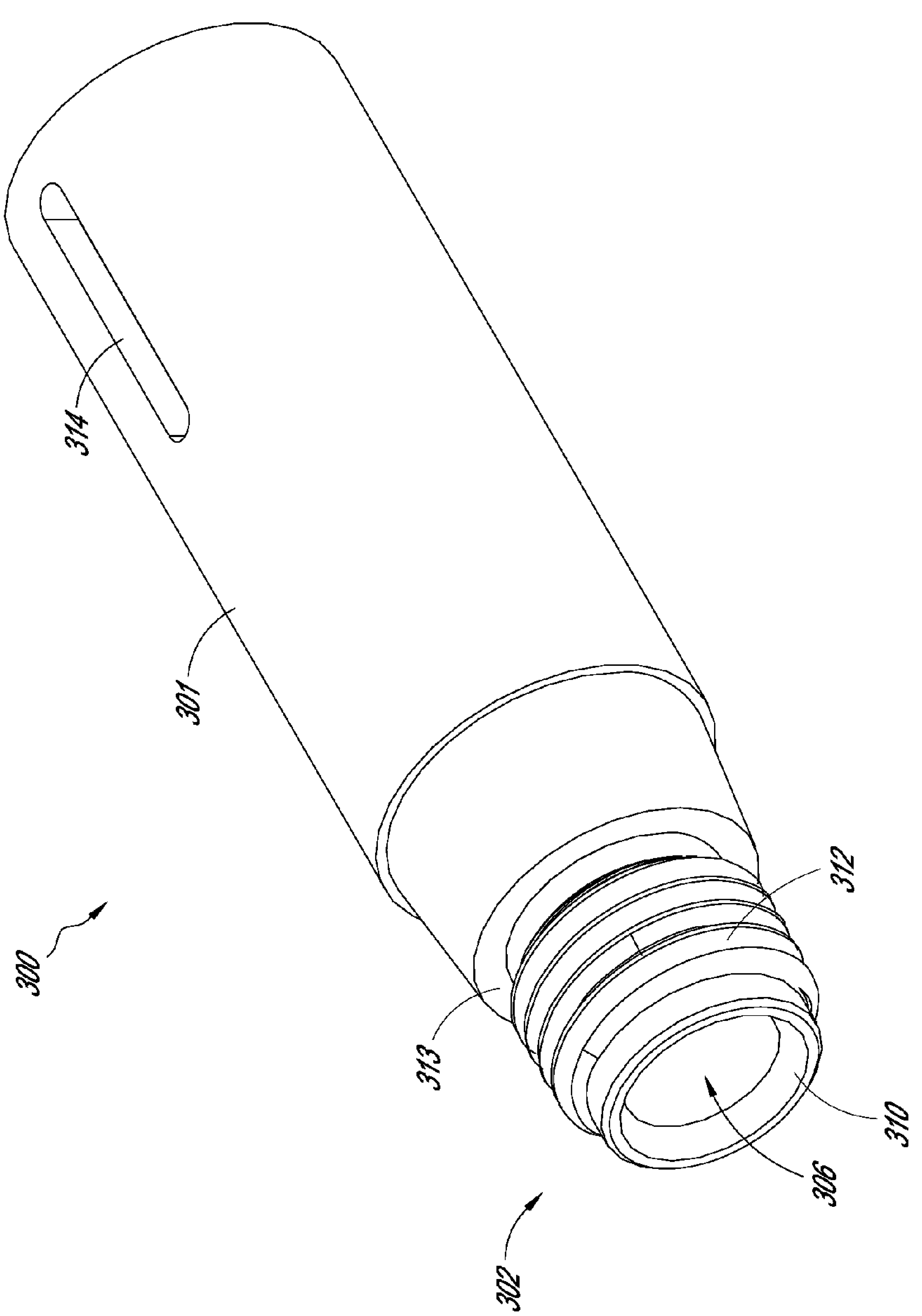

FIG. 3A

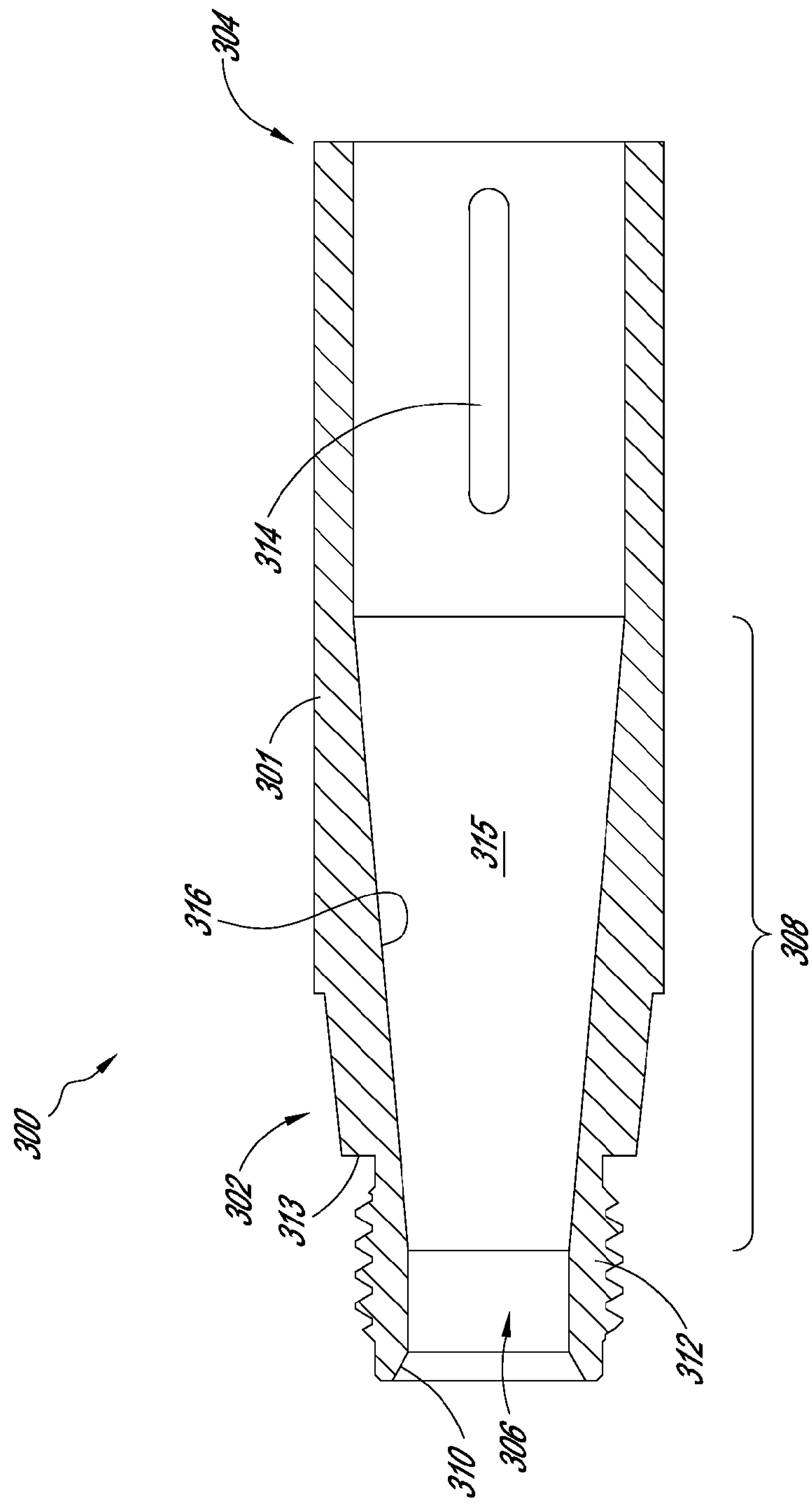

FIG. 3B

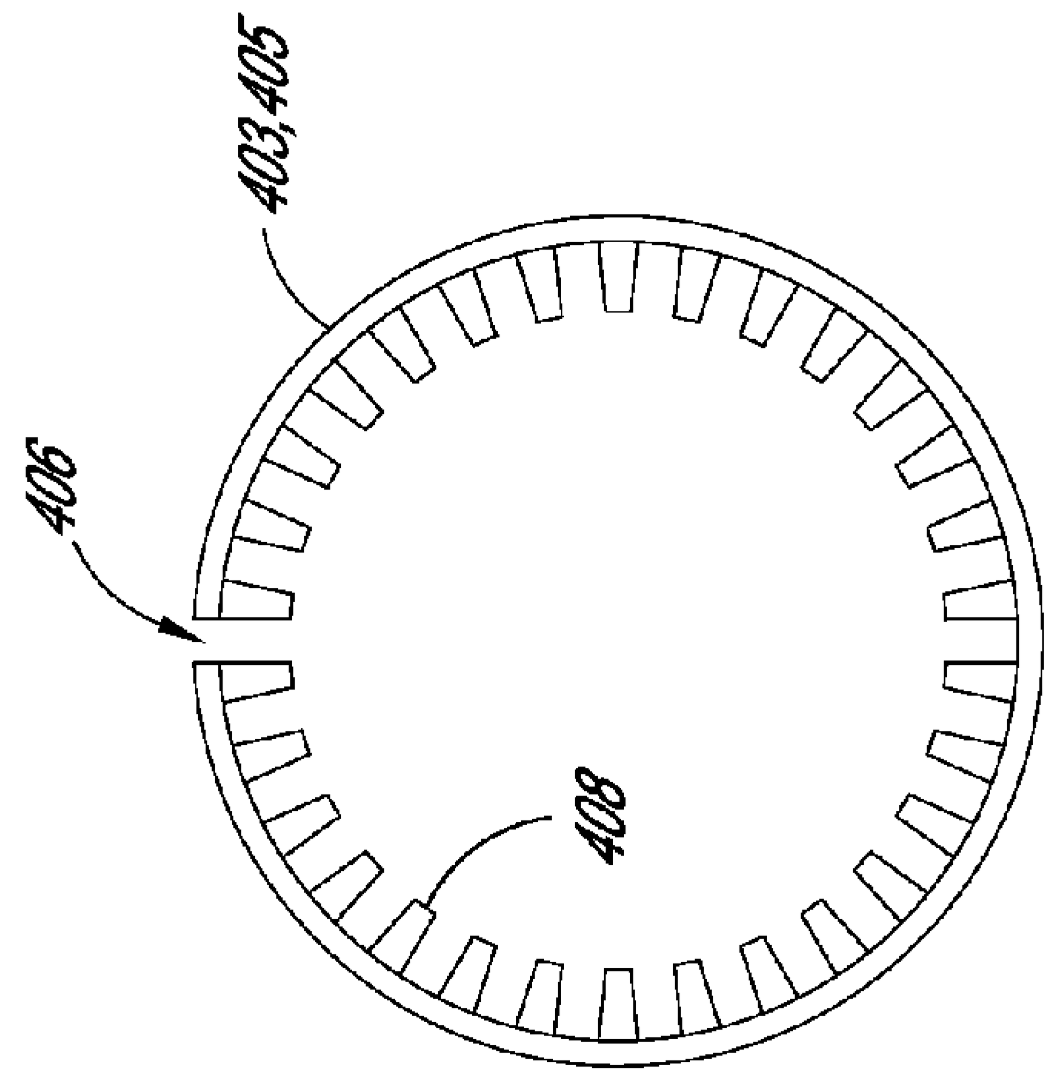

FIG. 4B

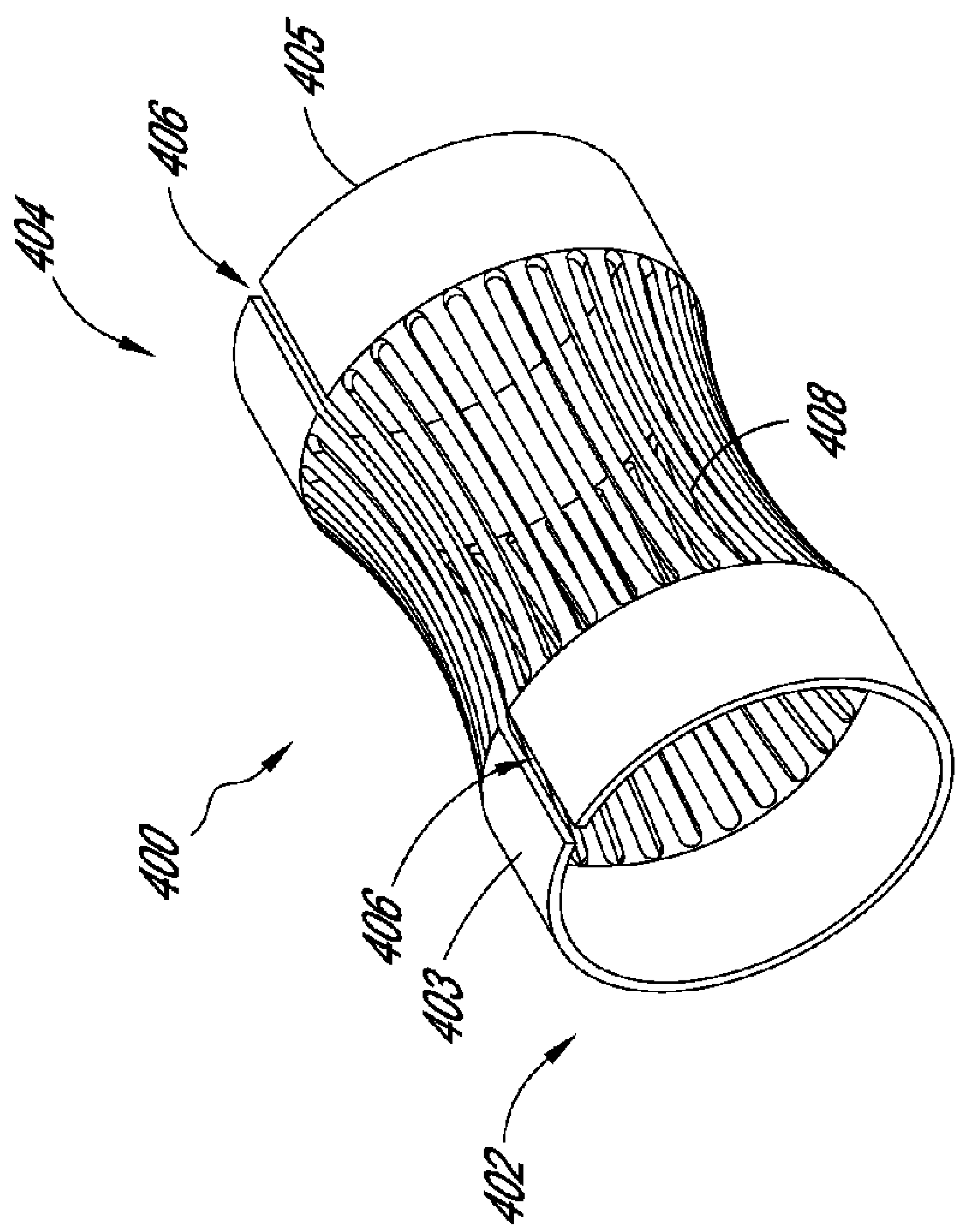

FIG. 4A

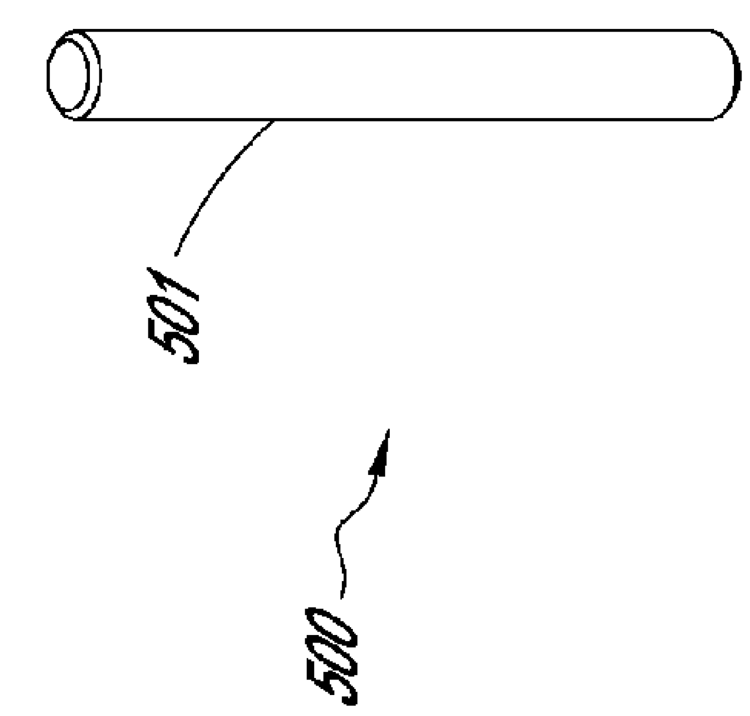

FIG. 5

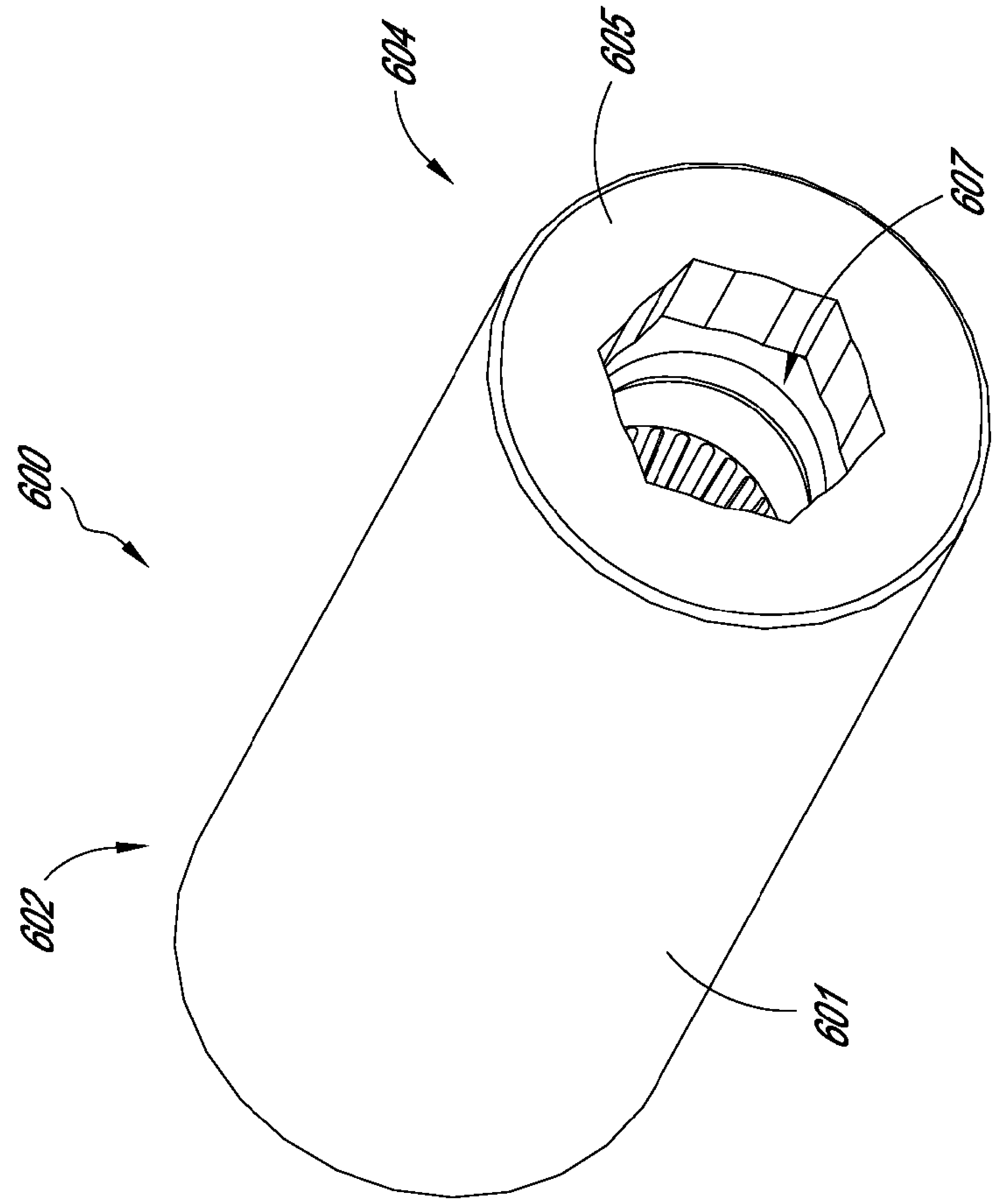

FIG. 6A

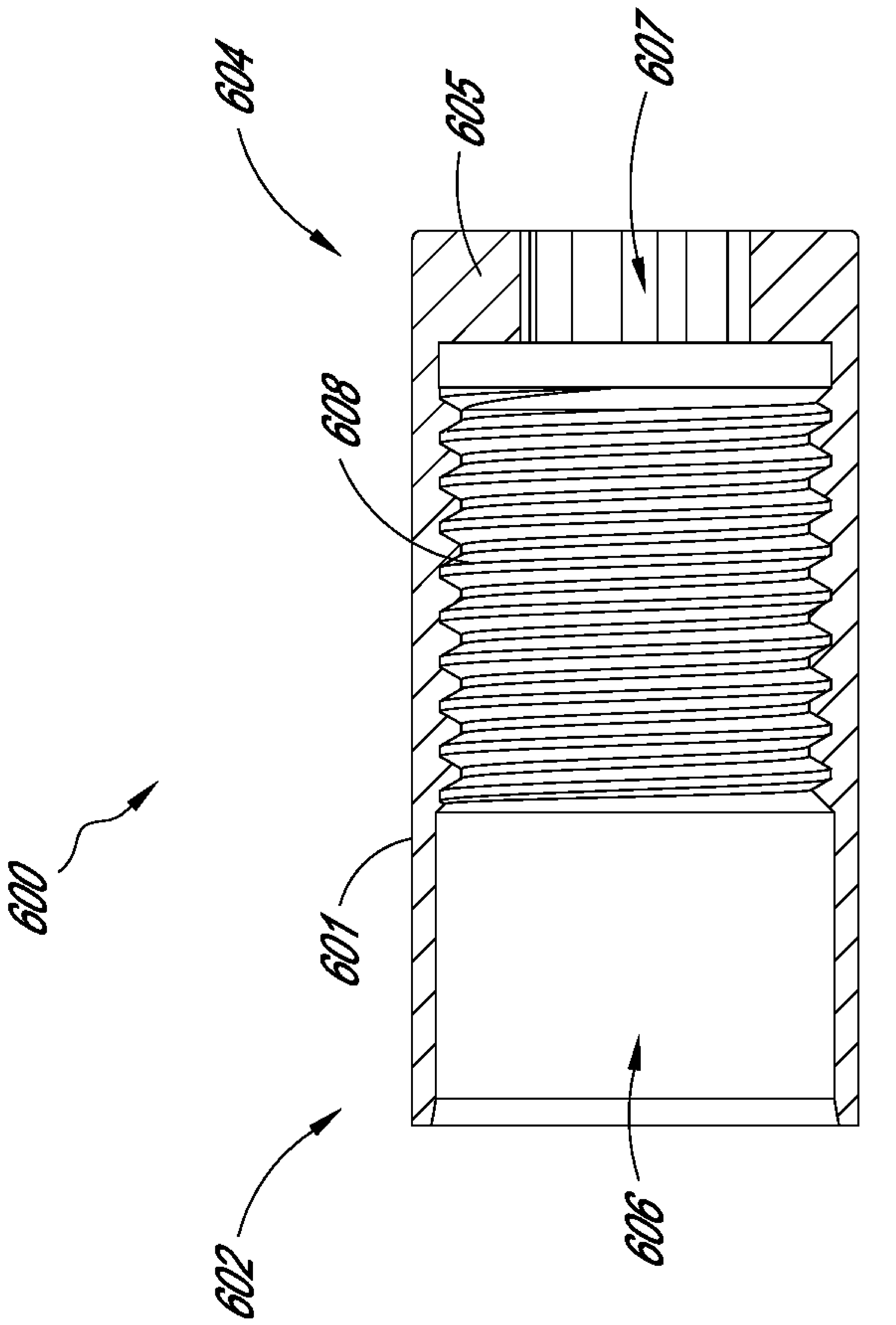

FIG. 6B

CRIMPLESS ELECTRICAL CONNECTORS

BACKGROUND

Field

This disclosure relates to connectors, such as electrical connectors for transmitting power or data electronically.

Description of Certain Related Art

Electrical connectors are devices that are used to join electrical conductors using a mechanical assembly. Electrical conductors can be used to transmit power or signals. Some electrical connectors are configured to connect a free end of a first conductor to a free end of a second conductor so that electricity can pass continuously from one conductor to another. In certain arrangements, an electrical connector can be a reversible coupling that allows the connection and disconnection of the first and/or second conductor.

SUMMARY OF CERTAIN FEATURES

Various embodiments of crimpless connector assemblies are disclosed. The crimpless connectors can comprise mechanical assemblies of various components. The components can include a crimpless contact, an outer housing, and a contact facilitator. Some embodiments can include an anti-rotation pin and an activation unit. Some of the components can be easily assembled with one another by inserting one component into a receiving end or slot of another component and easily disassembled by removing the inserted component from the receiving component. Some of the components can comprise threaded shafts configured to mate with threaded lumens or channels of another component, and can be easily assembled by screwing the components together and easily disassembled by unscrewing them. In some embodiments, the threaded components of the assembly can comprise different orientations (right-handed or left-handed) which can allow selective rotation of the components with respect to each other.

The assembly can include a first configuration, a second configuration, and intermediate configurations between the first and second configurations. The first configuration can be configured for receiving a conductor and the second configuration can be configured for physically securing the conductor, such as to resist a pull-out force. The crimpless contact can be configured to receive two electrical conductors at opposite ends and to establish an electrical connection between the two. In various embodiments, the clamping force increases when a user pulls on the first conductor.

The crimpless connector can include tines on one end for compressing the first conductor and/or physically securing it in the crimpless connector. The tines can be elastically deformed in the second configuration and/or various intermediate configurations under the applied compression.

The outer housing can be configured to mate with the crimpless connector and to apply a compression force to the tines. The outer housing can include a tapered lumen which modulates the compression depending on the distance the crimpless contact is inserted into the tapered lumen. The outer housing can also be configured to be secured within an external fixation structure, such as a dielectric insulator, and can prevent rotation of the outer housing and various other components of the assembly. In some implementations, the outer housing is secured to the external fixation structure such that relative rotation of the outer housing and the external fixation structure is inhibited or prevented in at least one rotational direction. For example, the outer housing can be secured to the external fixation structure with a threaded connection.

An anti-rotation pin can secure the outer housing to the crimpless contact in a manner that prevents one from rotating relative to the other. The anti-rotation pin can limit the amount of translation along the longitudinal axis between the outer housing and crimpless contact and can thereby regulate the amount of compression force exerted on the tines.

An activation unit, such as an activation nut, can be coupled to the crimpless contact, opposite the outer housing. Rotation of the activation unit can be used to control the insertion and/or retraction of the crimpless contact in the outer housing, thereby modulating the amount of compression force applied to the first conductor by the tines of the crimpless contact. The second conductor can be inserted into the opposite end of the crimpless contact as the first conductor. In some embodiments, the second conductor can be inserted through the activation unit. The crimpless contact can be coupled to a contact facilitator for facilitating a physical and electrical connection between the second conductor and the crimpless contact.

In some embodiments, a connector comprises an outer dielectric housing, a contact activation nut, an anti-rotation feature (e.g., a pin), a contact base with a tapered surface, and a crimpless contact with multiple tines. In some embodiments, rotation of the contact activation nut transfers an axial force to the crimpless contact, which pushes the crimpless contact along the tapered surface of the contact base, which in turn causes the tines to contract radially inwardly on a conductor. In some embodiments, the contact activation nut comprises an aperture that is configured to receive a conductor and to receive a tool (e.g., a hexagonal wrench) for use in rotating the contact activation nut. In some embodiments, the anti-rotation pin resides in a longitudinal slot and inhibits rotation of the contact activation nut relative to the outer dielectric housing. Various embodiments do not require crimping to establish an electrical connection and/or to secure a conductor in the connector.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A-**1**D illustrate an example of a crimpless connector assembly. FIG. **1**A is a perspective view of the crimpless connector in a first configuration. FIG. **1**B is a side cross-sectional view of the crimpless connector in a first configuration within an external structure. FIG. **1**C is a side cross-sectional view of the crimpless connector in a second configuration, within the external structure, and with first and second conductors installed. FIG. **1**D is an exploded view of the crimpless connector.

FIGS. **2**A-**2**B illustrate an example of a crimpless contact that can be used in the connector of FIGS. **1**A-**1**D. FIG. **2**A is a perspective view of the crimpless contact. FIG. **2**B is a side cross-sectional view of the crimpless contact.

FIGS. **3**A-**3**B illustrate an example of an outer housing that can be used in the connector of FIGS. **1**A-**1**D. FIG. **3**A is a perspective view of the outer housing. FIG. **3**B is a side cross-sectional view of the outer housing.

FIGS. **4**A-**4**B illustrate an example of a contact facilitator that can be used in the connector of FIGS. **1**A-**1**D. FIG. **4**A is a perspective view of the contact facilitator. FIG. **4**B is a side cross-sectional view of the contact facilitator.

FIG. **5** illustrates a perspective view of an example of an anti-rotation pin that can be used in the connector of FIGS. **1**A-**1**D.

FIGS. **6A-6**B illustrate an example of an activation nut that can be used in the connector of FIGS. **1A-1**D. FIG. **6**A is a perspective view of the activation nut. FIG. **6**B is a side cross-sectional view of the activation nut.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

Various embodiments of the disclosed invention relate to connectors for electrically joining two separate electrical conductors. Several embodiments comprise a crimpless connector. A crimpless connector can provide the electrical connection between two electrical conductors without substantially plastically deforming (e.g., crimping) the crimpless connector and/or the electrical conductors in order to form the electrical connection and/or to secure at least the first conductor in the connector. Crimpless connectors can be elastically deformable to secure the electrical connection between two conductors. Several of the crimpless connectors disclosed herein can be quickly assembled and disassembled. Several embodiments do not require the use of special crimping tools (e.g., crimping pliers) to secure the conductors within the crimpless connector. In some embodiments, neither the crimpless connector nor the conductors are substantially plastically deformed. In certain implementations, the conductors can be readily removed from the crimpless connector and can be used elsewhere or reinserted into the crimpless connector. Likewise, the crimpless connector can be reused with other conductors. In some embodiments, the crimpless connector can apply substantially uniform pressure to a conductor, such as by gripping the conductor around generally the entire circumference along a length of the conductor. The amount of pressure applied by the crimpless connector to the conductor can be modulated and can be easily increased or decreased.

Overview

An example of a crimpless connector **100** is shown in FIGS. **1A-1**D. As shown, the connector **100** can comprise a crimpless contact **200** and an outer housing **300**. Some embodiments have a contact facilitator **400**. Some embodiments include an anti-rotation pin **500** and/or an activation unit **600** (e.g., an activation nut). The components can be assembled together to comprise the crimpless connector **100** and can be unassembled as needed. The crimpless connector **100** can generally be assembled along a longitudinal axis L extending from a proximal end **102** to a distal end **104**. The outer housing **300** can be positioned at the proximal end **102** and the activation nut **600** can be positioned at the distal end **104**. The outer housing **300** can be configured to connect with an external fixation structure E, such as with a threaded connection. The outer housing **300** can be secured to the external structure E. The outer housing **300** can be generally fixed relative to the external structure E. The outer housing **300** can be inhibited or prevented from rotating relative to the external structure E in at least one rotational direction. In various embodiments, the external structure E comprises a dielectric insulator. In some embodiments, the external structure E extends along and/or surrounds substantially the entire longitudinal length of the connector **100**.

When assembled in an operative configuration, the components can be positioned in a first configuration, a second configuration, or various graduated intermediate configurations between the first and second configurations. FIG. **1**B shows the crimpless connector **100** in a first configuration. In some embodiments, in the first configuration, the crimpless connector **100** is configured for receiving a first conductor C**1**. FIG. **1**C shows the crimpless connector **100** in a second configuration. In some embodiments, in the second configuration, the crimpless connector **100** is configured for physically securing the first conductor C**1**. The first configuration can be a non-deformed configuration and the second configuration can be a deformed configuration. As will be described in greater detail below, the crimpless contact **200** can electrically connect two conductors (e.g., stranded cables, solid copper connectors, etc.). By physically receiving a free end of the first conductor C**1** and a second conductor C**2** within opposite sides of an elongate body, the crimpless connector **100** can serve as an electrical conduit between the two conductors C**1**, C**2**.

The proximal end **102** of the crimpless contact **200** can be configured with tines **250** for compressing and securing the free end of the first conductor C**1**. The proximal end **102** of the crimpless contact **200** can be received within a tapered lumen **315** of the outer housing **300**, which can act to compress the tines **250** onto the first conductor C**1**. For example, the tines **250** can engage with a tapered wall **316** of the lumen **315**. In some embodiments, the amount of compression is generally proportional to the distance in which the crimpless contact **200** is inserted along a longitudinal axis into the outer housing **300**. The pressure applied by the tines **250** on the conductor C**1** can inhibit and/or prevent retraction of the first conductor C**1** from the crimpless connector **100**.

In some embodiments, the crimpless contact **200** and the outer housing **300** are configured to rotate together as a unit. Some implementations include the anti-rotation pin **500** that joins the crimpless contact **200** and outer housing **300** in a manner that inhibits or prevents their rotation relative to one another about the longitudinal axis L. In some embodiments, the crimpless contact **200** and outer housing **300** are configured to translate relative to each other, such as along the longitudinal axis and/or along the direction of the taper.

As shown, the crimpless contact **200** can be threaded to engage the threads of an activation nut **600**. The crimpless contact **200** and activation nut **600** can be generally aligned along a common longitudinal axis, through which a portion of the second conductor C**2** can extend. Rotation of the activation nut **600** in a first direction can result in an axial separation with the crimpless contact **200** and/or can translate the crimpless contact **200**. This can cause the crimpless contact **200** to move deeper into the outer housing **300**. As mentioned above, the outer housing **300** can be secured to the external structure E, which can maintain the outer housing **300** in a generally fixed position relative to the external structure E. The crimpless contact **200** can move (e.g., translate) relative to the outer housing **300** and the external structure E. In some embodiments, movement of the crimpless contact **200** relative to the outer housing **300** moves the tines **250** along the tapered wall **315**. This can result in the tines **250** being deformed radially inward, thereby compressing the tines **250** against the first conductor C**1**. In some variants, the distal end **104** of the crimpless contact **200** can include a contact facilitator **400** for facilitating electrical contact between the crimpless contact **200** and the second conductor C**2**. In some implementations, such as is shown in FIGS. **1**B and **1**C, the distal end of the activation nut **600** engages (e.g., bears against) the external structure E. In some embodiments, the external structure E inhibits or prevents the activation nut **600** and/or the housing **300** from translating relative to the external structure E. In some variants, the crimpless contact **200** and/or the pin **500** translates relative to the external structure E, such as in response to rotation of the nut **600**, as will be described in more detail below. In certain variants, the proximal and distal ends **102**, **104** of the connector **100** are longitudinally restrained by and/or captured in the external structure E. In some embodiments, the external structure E comprises multiple discrete components. For example, a portion of the external structure E that engages the proximal end **102** can be a separate component from a portion of the external structure E that engages the distal end **104**. In some variants, the external structure E is a unitary component.

Crimpless Contact

FIGS. **2**A-**2**B illustrate an example of the crimpless contact **200**. The crimpless contact **200** can be configured to receive and conduct electricity between two electrical conductors. As illustrated, the crimpless contact **200** can include an elongate body **201**, comprising a proximal end **202** and a distal end **204**. The elongate body **201** can be generally cylindrical or other shapes. The proximal end **202** can include tines **250** configured to receive and compress the first conductor C**1**. In some embodiments, the tines **250** bound a passage **251** into which the first conductor C**1** is received. As discussed in more detail below, the tines **250** can be deformed, thereby changing the diameter of the passage **251**.

In some embodiments, the proximal end **202** is positioned in the housing **300**. The proximal end **202** can be configured to be received within the distal end **304** of the outer housing **300**. In some embodiments, and/or the distal end **204** is positioned out of the housing **300**, such as protruding distally out of the housing **300**. The distal end **204** can comprise a threaded portion **210** configured to mate with the activation nut **600**. The distal end **204** can be configured to receive the second conductor C**2**.

The proximal end **202** and the distal end **204** of the crimpless contact **200** can each comprise a channel **203**, **205**, extending from their respective end-faces along the longitudinal axis toward the longitudinal center of the crimpless contact **200**. In some implementations, the proximal channel **203** and distal channel **205** can comprise similar diameters and/or can be longitudinally aligned. The crimpless contact **200** can comprise an interior portion **206** that separates inner ends **207**, **209** of the channels **203**, **205**. The inner ends **207**, **209** of the channels **203**, **205** can be conically shaped for receiving the ends of the first and second conductors C**1**, C**2**, respectively. The conical inner ends **207**, **209** can facilitate manufacturability of the contact **200**. The length of the channels **203**, **205** can be about the same, as shown in FIG. **3**B, or can be different. A portion **208** of the distal channel **205** can comprise a slightly expanded diameter configured for receiving the contact facilitator **400**, as shown in FIGS. **1**B and **1**C. The expanded diameter portion **208** can be offset from the distal end-face of the crimpless contact **200** so that the contact facilitator **400** can be secured within the distal channel **205** without easily sliding out. The open end-face of the distal end **204** of the elongate body **201** can comprise a beveled sidewall **214** for facilitating insertion of the second conductor C**2** into the distal channel **205**. The beveled opening can comprise an angled surface, a rounded surface, or any other suitable shape. The open end-face of the proximal end **202** of the elongate body **201** can be beveled as described below in relation to the tines **250**.

The tines **250** can comprise the proximal-most end of the crimpless contact **200**. The tines **250** can comprise circumferential portions of the elongate body **201**. The tines **250** can be separated by slits **252**. The slits **252** can extend from the proximal end-face of the elongate body **201** in a direction generally parallel to the longitudinal axis. The length of the slits **252** along the longitudinal axis can be the same as or less than the length of the proximal channel **203**. The length of the slits **252** in the example of FIG. **3**B is less than the length of the proximal channel **203**. In some embodiments, the slits **252** radially extend between the outer diameter of the elongate body **301** and an inner diameter formed by the proximal channel **203**. The slits **252** can be uniformly spaced around the circumference of the elongate body **201**. The width of each of the slits **252** can be uniform and/or can be configured so that each tine **250** has an arcuate curvature (e.g., generally convex to the longitudinal axis L). In some embodiments, an arcuate curvature can facilitate compression of the tines **250** in a radial direction. Tines **250** with smaller arcs can be easier to compress radially inward than tines **250** with longer arcs. The width of each of the tines **250** can be uniform along the length of the tine **250** and/or compared to other tines **250**. There can be one or more tines **250** (e.g., one, two, three, four, five, six, etc.). The example shown in FIGS. **3**A-**3**B comprises four generally uniform width tines **250** separated by four generally uniform width slits **252**. The width of the slits **252** can be larger, such as in some embodiments with fewer tines **250**, to reduce the width of the tines **250**. This can allow for easier deformation of the tines **250**. In some embodiments, the tines **250** have a generally "C" shape in cross-section and/or at the proximal tip when viewed along the longitudinal axis from the proximal end.

As the tines **250** are radially compressed, the widths of the slits **252** can gradually decrease along the length of the tines **250** according to the amount of compression experienced. For example, when the crimpless contact **100** is positioned in the second configuration (e.g., a deformed configuration), the width of the slits **252** at the distal ends of the tines **250** can remain unchanged while the width of the slits **252** at the proximal ends of the tines **250** can be approximately zero. The width of the slits **252** can limit the amount of radial compression achievable by the tines **250**. In some embodiments, in the second configuration, the proximal ends of the tines **250** come into contact with each other, thereby forming a substantially continuous circumferential surface. When the tines **250** are in contact with each other, the tines **250** can be unable to be compressed any further.

In some embodiments, the width of the slits **252** varies in the longitudinal direction. In some embodiments, the width of the slits **252** in a first configuration (e.g., a non-deformed configuration) can decrease as the slits **252** extend distally. In some variants, in the first configuration, the width of the slits **252** increases as the slits **252** extend distally. In some embodiments, the width of the tines **250** increase as the width of the slits **252** decrease. The increased width of the slits **252** at the proximal end of the tines **250** can allow for greater deformation of the tines **250**.

The elongate body **201** can comprise one or more annular grooves **254**, **256**. The annular grooves **254**, **256** can reduce the thickness of the tines **250** at certain regions, which can encourage the tines **250** to bend at those regions when under radial compression (e.g., in response to the activation nut **600** being turned). Certain embodiments, such as the example shown in FIGS. **3**A-**3**B, include an annular groove **254** positioned along the outer circumference of the elongate body **201** and/or an annular groove **256** positioned along the inner circumference of the elongate body **201** near the middle of the tines **250**. As shown, in some embodiments, the annular groove **254** is at or near the distal end of the tines **250** and/or the annular groove **256** is at or near the middle of the tines **250**. The elongate body **201** can include any number of the grooves **254**, **256** along the length of the tines **250** or otherwise. For example, some embodiments have one, two, three, four, five, or more of the groove **254** and/or the groove **256**. The grooves **254**, **256** can be positioned on the inner circumference and/or the outer circumference of the elongate body **201**. In some variants, one or more of the grooves **254**, **256** can be positioned on the inner circumference at a length opposite one or more grooves positioned on the outer circumference. The grooves can be generally round, as shown in FIGS. **3A-3B**, or can comprise different shapes (e.g., rectangular cross-sections). The elongate body **201** can comprise grooves of different shapes and/or dimensions. The grooves may or may not extend around the entire circumference of the elongate body **201**. In some variants, different tines **250** can have different groove patterns.

The thickness of the tines **250** can decrease from the distal end of the tines **250** to the proximal end-face of the elongate body **201**, or along a portion therein. A reduction in the thickness can allow easier bending of the tines **250** as they are compressed by the tapered lumen of the outer housing **300**. The thickness can be more greatly reduced at more proximal portions of the tines **250** because those portions can experience more compression. In some embodiments, the thickness can be decreased by tapering the outer diameter, the inner diameter, or both the outer and inner diameter of the elongate body **201**. In the example shown in FIGS. **3A-3B**, the outer diameter tapers inward from the second annular groove **256** to the proximal end-face, decreasing the thickness of the tines **250** toward the proximal end of the crimpless contact **200**.

As shown, the tines **250** can comprise a textured surface **258**. The surface **258** can be configured to engage against (e.g., bite into) the first conductor C**1**. The textured surface can facilitate gripping and/or securing the first conductor C**1** in the contact **200**. In some implementations, when under compression, the surface **258** can enhance the grip of the tines **250** on the first conductor C**1**. The enhanced grip can contribute to the ability of the crimpless connector **100** to resist pull-out of the first conductor C**1** when the crimpless connector **100** is in a second configuration (e.g., a deformed configuration).

The textured surface **258** can comprise of any suitable texturing, such as ridges, ribs, grooves, bumps, combinations thereof, etc. In some embodiments, the surface **258** comprises a tooth or teeth. The textured surface **258** can extend over a portion or the entirety of the longitudinal length and/or the circumferential width of the tines **250**. The example shown in FIGS. **2A-2B** comprises a textured surface **258** formed by a series of adjacent grooves with pointed ridges between them. As illustrated, the surface **258** can extend from the second annular groove **256** to near the proximal end-face of the elongate body **201**. The proximal ends of the tines **250** can comprise beveled tips **259**. This can facilitate insertion of the first conductor C**1** into the proximal channel **302**.

The threaded portion **210** of the elongate body **201** of the crimpless contact **200** can comprise the distal most portion of the elongate body **201**. The threads of the threaded portion **211** can be oriented in a first orientation (e.g., right-handed or left-handed) and can be configured to mate with a threaded channel of the activation nut **600**. The length of the threaded portion **210** can be the same, greater than, or less than the length of the distal channel **205**. In the example shown in FIGS. **2A-2B**, the length of the threaded portion **210** is less than the length of the channel **205**. The outer diameter of the threaded portion **210** can be configured to be substantially flush with the outer diameter of the adjacent non-threaded portion of the elongate body **201**. In some embodiments, a non-threaded portion of the inner diameter of the activation nut **600** can slidingly engage the non-threaded portion of the outer diameter of the crimpless contact **200** when assembled together, as shown in FIGS. **1B** and **1C**.

The interior portion **206**, which can be located longitudinally between the proximal channel **203** and the distal channel **305**, can comprise a bore **212** extending through the elongate body **201**. The bore **212** can be generally straight and/or generally perpendicular to the longitudinal axis. The bore **212** can pass through the longitudinal axis along a diameter of the elongate body **201**. The bore **212** can comprise at least two openings within the elongate body **201**. The two openings can be positioned about 180 degrees from each other. The bore **212** can be generally cylindrical.

The bore **212** can comprise a diameter configured to receive the outer diameter of an anti-rotation pin **500**. The anti-rotation pin **500** can be used to secure the crimpless contact **200** to the outer housing **300** and/or to inhibit or prevent relative rotation between the crimpless contact **200** and the outer housing **300**. In some embodiments, the bore **212** does not radially extend through the entire elongate body **201**. For example, the bore **212** can terminate within the interior portion **206**. In such embodiments, the anti-rotation pin **500** can only extend through one radial side of the outer housing **300** and crimpless contact **200** to secure the two components together. In some embodiments, the pin **500** extends through both radial sides of the outer housing **300** and the crimpless contact **200**.

Outer Housing

FIGS. **3A-3B** illustrate an example of the outer housing **300**. The outer housing **300** can be configured to receive the proximal end of the crimpless contact **200**. In various embodiments, engagement of the outer housing **300** and the crimpless contact **200** facilitates securing the crimpless contact **200** to the first conductor C**1**. For example, as previously mentioned, the engagement of the crimpless contact **200** and the tapered wall **316** can radially compress the tines **250** against the first conductor C**1**. The tines **250** can provide a clamping force on the first conductor C**1**. In several embodiments, the clamping force increases in response to the first conductor C**1** being pulled.

As shown, the outer housing **300** can comprise an elongate body **301** that includes a proximal end **302** and a distal end **304**. The elongate body **301** can be generally cylindrical. The proximal end **302** can be configured to receive and/or couple the first conductor C**1** and the distal end **304** can be configured to couple with the crimpless contact **200**.

The outer housing **300** can comprise a lumen **306** (also called a conduit). The lumen **306** can extend along a longitudinal axis from the proximal end **302** of the outer housing **300** to the distal end **304** of the outer housing **300**. The housing lumen **306** can be generally cylindrical and can comprise an inner diameter at its distal end **304** that is configured to slidably receive the outer diameter of the proximal side of the crimpless contact **200**. The open end-face of the distal end **304** of the elongate body **301** can comprise a flat-faced sidewall for abutting the activation nut **600**. In some embodiments, the outer housing **300** insulates a portion of the crimpless contact **200** from the ambient environment.

In several embodiments, the housing lumen **306** comprises the tapered lumen **315**. At least a portion of the length of the housing lumen **306** can comprise a decreasing inner diameter as the lumen **306** extends distally, such as from the distal end **304** toward the proximal end **302** of the outer housing **300**. The length over which the inner diameter decreases comprises a tapered portion **308**. The rate of change in the inner diameter can be constant such that the taper is linear. In some embodiments, the rate of change can be non-linear (e.g., the tapered portion **308** can comprise a rounded convex surface, a rounded concave surface, or a surface having incremental step changes in diameter). In some embodiments, as shown in FIG. 3B, a length of the housing lumen **306** on the distal end **304** comprises a fixed diameter and/or a length of the housing lumen **306** on the proximal end **302** comprises a fixed diameter. The length of the tapered portion **308** along the longitudinal axis can be configured to be at least the longitudinal length of the tines **250** of the crimpless contact **200**.

The tapered portion **308** can be configured to coordinate and/or engage with the tines **250**. In several embodiments, when the crimpless connector **100** is in the second configuration, the tines **250** extend substantially the entire longitudinal length of the tapered portion **308**. The shape of the taper formed by the tapered portion **308** can match or resemble the shape of the tines **250**. For example, the angle of the taper can match or approximate the angle of the outer surface of the tines **250** when they are in the second configuration. The length of the housing lumen **306** between a distal end of the tapered portion **308** and the open end-face of the distal end **304** of the elongate body **301** can be equal to or less than a length of the crimpless contact **200** between the distal end of the tines **250** and the position where the activation nut **600** sits on the crimpless contact **200** in the second configuration. The length of the housing lumen **306** between the proximal end of the tapered portion **308** and the open end-face of the proximal end **302** can comprise an inner diameter that is less than or equal to the smallest diameter of the tapered portion and can be any suitable length.

The proximal end **302** can include insertion facilitating features. In some embodiments, the proximal end **302** of the tapered portion **308** comprises the open end-face of the proximal end **302** of the elongate body **301**. The open end-face of the proximal end **302** of the elongate body **301** can comprise a beveled sidewall **310**. This can facilitate insertion of the first conductor C**1** into the housing lumen **306**. The beveled sidewall **310** can comprise an angled surface, a rounded surface, or any other suitable shape.

As illustrated, the outer diameter of the elongate body **301** can comprise a threaded portion **312**. The threads of the threaded portion **312** can be oriented in a second orientation (e.g., right-handed or left-handed). The second orientation of the threads can be opposite the first orientation of threads discussed above. The threaded portion **312** can be configured to mate with threads of an external structure, such as a dielectric insulator, to which the crimpless connector **100** can be joined and/or embedded in. As shown in FIG. 3B, the outer diameter of the threaded portion **312** of the elongate body **301** can be less than the outer diameter of a distal portion of the elongate body **301**. This can allow easy insertion of the threaded portion **312** into a threaded lumen of an external structure and/or can create a shoulder **313** for abutting with a surface of the external structure (e.g., when the threaded portion **312** is fully inserted). The shoulder **313** can inhibit or prevent further longitudinal translation of the outer housing **300** in the proximal direction during assembling of the crimpless connector **100** into the external structure (not shown). In some embodiments, when the threaded portion **312** is fully inserted to the point of an abutment, the threads can inhibit or prevent rotation of the outer housing **300** in a first direction (clockwise or counterclockwise). The length of the threaded portion **312** can be any suitable length. The outer housing **300** can comprise other variations in its outer diameter along the length of the elongate body **301**. These variations can configure the outer housing **300** for mating with the external structure (e.g., dielectric insulating shell). In some embodiments, the housing **300** is made of a dielectric material.

The outer housing **300** can comprise one or more (e.g., two) elongated pin slots **314** in the sidewall of its elongate body **301**. As shown, the pin slots **314** can be at or near the distal end **304**. The pin slots **314** can be generally elongated in shape, such as having a length at least three times the width. The pin slots **314** can extend in a direction generally parallel with the longitudinal axis. The pin slots **314** can have identical shapes and lengths. The width of the pin slots **314** can be configured to receive a portion of the anti-rotation pin **500**. In some embodiments, the anti-rotation pin **500** does not substantially move or rotate in a circumferential direction relative to the outer housing **300** and/or crimpless contact **200**. The width of the pin slots **314** can be greater than or equal to the diameter of the bore **212** of the crimpless contact **200**. The pin slot **314** can be configured to allow the anti-rotation pin **500** to translate, such as in a direction generally parallel to the longitudinal axis between a proximal end and a distal end of the pin slot **314**. The pin slots **314** can be positioned about circumferentially opposite each other (e.g., about 180 degrees apart). The pin slots **314** can be substantially aligned along and/or generally parallel to the longitudinal axis. In some embodiments, the anti-rotation pin **500** extends generally perpendicularly to the longitudinal axis through one pin slot **314**, across the diameter of the elongate body **301**, and through the second pin slot **314**.

The length of the pin slots **314** can modulate the amount of translation between the assembled outer housing **300** and the crimpless contact **200** and the total distance into the outer housing **300** that the crimpless contact **200** can extend. By doing so, the length of the pin slots **314** can modulate the amount of compression achievable by the tines **250**. In some embodiments, the length of the pin slots **314** can be the same as or less than the length of the tines **250**. In certain implementations, the crimpless contact **200** is not insertable to an extent where portions of the crimpless contact **200** proximal to the tines **250** are encountering and/or engaging the tapered portion **308** of the outer housing **300**. Some embodiments comprise one pin slot **314** configured such that an inserted anti-rotation pin **500** is only able to extend through the one pin slot **314** and into the elongate body **301**.

Contact Facilitator

FIGS. **4A-4B** illustrate an example of the contact facilitator **400**. The contact facilitator **400** can be configured to be received between the distal channel **205** of the crimpless contact **200** to facilitate an electrical connection between the crimpless contact **200** and the second conductor C**2**, which can be inserted through the contact facilitator **400**. As shown, the contact facilitator **400** can comprise a generally cylindrical body comprising a proximal end **402** and a distal end **404**. The cylindrical body can include a proximal ring-like portion **403** and a distal ring-like portion **405**. The proximal and distal ring-like portions **403**, **405** can each comprise a thin annular body and a gap **406** extending parallel to the longitudinal axis from a proximal side to a distal side of the ring-like portion **403**, **405**. The gaps **406** can comprise a small fraction of the circumference of the annular bodies of the ring-like portions **403**, **405**. The ring-like portions **403**, **405** can comprise similar or identical diameters and gaps **406** of similar or identical widths. The ring-like portions **403**, **405** can be substantially circumferentially aligned so that the gaps **406** are generally aligned along a straight axis.

The contact facilitator **400** can further comprise a series of circumferentially spaced struts **408** extending between the distal end of the proximal ring-like portion **403** and the proximal end of the distal ring-like portion **405**. The struts **408** can be generally parallel to the longitudinal axis and can be substantially uniformly spaced about the circumference of the contact facilitator **400**. The struts **408** can have substantially uniform widths. The contact facilitator **400** can include any suitable number of struts, including, but not limited to, 1-100 struts, 3-80 struts, 4-60 struts, 5-50 struts, 6-45 struts, 8-40 struts, 10-35 struts, 20-30 struts, ranges in between, more than 100 struts, etc. The struts **408** can curve radially inward between the proximal ring-like portion **403** and the distal ring-like portion **405**. The struts **408** can all have similar or identical curvatures. The struts **408** can extend a maximal radial distance inward approximately half way between the proximal ring-like portion **403** and the distal ring-like portion **405**, where they comprise an inner diameter of the contact facilitator **400**. The outer diameter of the proximal and distal ring-like portions **403**, **405** can comprise an outer diameter of the contact facilitator **400**.

The outer diameter of the contact facilitator **400** in a non-deformed configuration can be configured to be received in the expanded diameter portion **208** of the crimpless contact **200**. When the ring-like portions **403**, **405** are compressed radially inward, they can temporarily assume a diminished diameter configuration configured to be received through the distal-most portion of the distal channel **205**. The width of the gaps **406** in the circumferences of the ring-like portions **403**, **405** can be temporarily reduced when the ring-like portions **403**, **405** are compressed (e.g., the width of the gaps can be reduced to about zero). The length of the contact facilitator **400** in a non-deformed configuration can be slightly less than the length of the expanded diameter portion **208** of the crimpless contact **200**. The struts **408** can be configured to be pressed radially outward by the second conductor C**2** when the second conductor C**2** is inserted through the contact facilitator **400**. When pressed radially outward, the curvature of the struts **408** can be reduced, expanding the length of the struts **408** along a proximal-to-distal direction and increasing the separation distance between the proximal and distal ring-like portions **403**, **405**. The length of the expanded diameter portion **208** of the crimpless contact can be configured to accommodate the expanded length of the contact facilitator when deformed by the second conductor C**2**.

Anti-Rotation Pin

FIG. **5** illustrates an example of the anti-rotation pin **500**. Some implementations of the crimpless connector **100** can include an anti-rotation pin **500** configured to inhibit or prevent the crimpless contact **200** and the outer housing **300** from rotating relative to one another about the longitudinal axis of the connector **100**. As shown, the anti-rotation pin **500** can comprise an elongate body **501**. The anti-rotation pin **500** can be generally cylindrical. The cross-sectional view of the crimpless connector **100** shown in FIG. **1**B illustrates the anti-rotation pin **500** assembled with the crimpless contact **200** and the outer housing **300** in a first configuration. FIG. **1**C illustrates the anti-rotation pin **500** assembled with the crimpless contact **200** and the outer housing **300** in a second configuration.

As mentioned above, the anti-rotation pin **500** can be configured to be received within the bore **212** of the crimpless contact **200** and/or the pin slots **314** of the outer housing **300**. The anti-rotation pin **500** can comprise a length greater than or equal to the length of the bore **212** of the crimpless contact **200** and/or a length greater than or equal to the outer diameter of the distal end **304** of the elongate body **301** of the outer housing **300**. The anti-rotation pin **500** can extend the entire length of the bore **212** and extend into or through one or two pin slots **314**, thereby substantially securing the outer housing **300** and the crimpless contact **200** together in the circumferential direction. The length of the anti-rotation pin **500** can be less than or equal to the outer diameter of the distal end **304** of the elongate body **301** of the outer housing **300**. The diameter of the anti-rotation pin **500** can be slightly less than the diameter of the bore **212** and/or slightly less than the width of the pin slots **314**.

Activation Unit

FIGS. **6**A-**6**B illustrate an example of the activation unit **600**. The activation unit **600** can be operatively configured to transition the crimpless connector **100** between the first configuration (e.g., for allowing easy insertion and removal of the first conductor C**1**) and the second configuration (e.g., for resisting pull-out of the first conductor C**1**). As shown, the activation unit **600** can generally be configured as an activation nut. The activation nut **600** can be configured to receive the distal end **204** of the crimpless contact **200**. The activation nut **600** can comprise a generally cylindrical body **601** having a proximal end **602** and a distal end **604**. The proximal end **602** can comprise a generally open end-face and the distal end **604** can comprise a flat, generally closed end-face **605**.

The activation nut **600** can include a channel **606** extending from the proximal open end-face **602** to the proximal side of the distal closed end-face **605**. The channel **606** can comprise a threaded portion **608**. The threaded portion **608** can be positioned near the distal end of the channel **606** and can be configured to mate with the threaded portion **212** of the crimpless contact **200**. The length of the threaded portion **608** of the channel **606** can be greater than or equal to the length of the threaded portion **212** of the crimpless contact **200**. The threads of the threaded portion **608** can be oriented in a first orientation (e.g., right-handed or left-handed). The first orientation can be opposite the second orientation of the threaded portion **312** of the outer housing **300**. For example, the threaded portion **608** can comprise right-hand threading and the threaded portion **212** can comprise left-hand threading, or vice versa. The opposite threading can reduce the chance of the crimpless connector **100** being unthreaded from the external structure (e.g., dielectric shell) when the activation nut **600** is turned.

The channel **606** can comprise an unthreaded portion proximal to the threaded portion **608**. The unthreaded portion can be configured to slidably receive the outer diameter of the distal end **204** of the crimpless contact **200**, such as an unthreaded portion proximal to the threaded portion **212** of the crimpless contact **200**. The length of the unthreaded portion can extend such that the proximal end **602** of the activation nut **600** abuts the outer housing **300**. In some embodiments, the activation nut **600** can aid in insulating portions of the crimpless contact **300** from the ambient environment.

The closed-end face **605** can include an aperture **607**. The aperture **607** can extend from the proximal side to the distal side of the closed-end face **605**. The aperture **607** can be generally aligned along the longitudinal axis. The aperture **607** can be configured to receive the second conductor C**2**. The second conductor C**2** can extend through the aperture **607** of the activation nut **600** into the distal channel **205** of the crimpless contact **200**. The aperture **607** can be configured to receive an activation tool (e.g., a hexagonal wrench) for rotating the activation nut **600**, thereby transitioning the crimpless contact **200** between the first and second configurations. The aperture **607** can be polygonal (e.g., pentagonal, hexagonal, octagonal, etc.) or any shape configured to mate with a complementary shaped or at least partially complementary shaped activation tool. The activation tool can rotate the activation nut **600** by applying a torque to the activation nut **600** about the longitudinal axis. The closed end-face **605** can be sufficiently thick and/or strong for the activation tool to frictionally mate with the aperture **607**.

In some embodiments, the activation nut **600** can be turned by applying a torque to the outer diameter of the activation nut **600**. In certain implementations, the outer diameter of a portion of the activation nut **600** can be configured to facilitate the application of torque to the activation nut **600**. For example, the outer diameter can comprise one or more flattened surfaces or can be polygonal for mating with a wrench or other suitable activation tool. In some implementations, the activation nut **600** can be manually turned by a user without the use of an activation tool. A portion of the outer surface of the activation nut **600** can be textured for facilitating the grip of a user.

Assembly, Disassembly, and Operation of the Connector

Various components disclosed herein can be reversibly assembled into the crimpless connector **100**. Referring back to FIGS. **1A-1C**, an example of the assembled crimpless connector **100** is shown. FIGS. **1A** and **1B** depict the crimpless connector in the first configuration (a non-deformed configuration). FIG. **1C** depicts the crimpless connector in the second configuration (a deformed configuration). The components can generally be assembled in any order. In some implementations, the contact facilitator **400** is configured to be inserted into the crimpless contact **200** prior to coupling the crimpless contact **200** with the activation nut **600**. In some implementations, the anti-rotation pin **500** is configured to be inserted through the crimpless connector **100** after the coupling of the crimpless contact **200** and the outer housing **300**.

The proximal end **202** of the crimpless contact **200** can be received in the distal end **304** of the outer housing **300**. A user (e.g., an assembler) can slidably insert the proximal end **202** of the crimpless contact **200** into the outer housing **300** approximately until a point where a resistance is sensed. The resistance can be caused by the frictional interaction between the tines **250** and the tapered portion **308** of the outer housing **300**. The assembler can rotate the crimpless contact **200** in either direction until an opening to the bore **212** in the crimpless contact **200** is visibly aligned with a pin slot **314** in the outer housing. The assembler can align the pin slot **314** with the bore **212**, such as prior to or during the insertion of the crimpless contact **200** into the outer housing **300**. In some embodiments, the connector **100** is configured to enable the assembler to gauge the length of insertion by visually discerning the longitudinal alignment of the bore **212** within the length a pin slot **314**. The assembler can adjust the length of insertion so that the bore **212** is aligned at the distal end of a pin slot **314**. This configuration can comprise the first configuration.

In some embodiments, the first configuration comprises a non-deformed configuration, in which the tines **250** are not compressed radially inward and the width of the slits **252** between the tines **250** remains substantially unchanged. In some embodiments, the first configuration comprises a slightly deformed configuration. For example, the tines **250** can be compressed radially inward such that the passage **251** has a diameter greater than the diameter of the first conductor C**1** but less than the diameter of the passage **251** when the crimpless contact **200** is separate from the outer housing **300**. The portion of the tines **250** received within the tapered portion **308** of the outer housing **300** in the first configuration can be configured with an outer diameter that decreases in the proximal direction to create angled surface. The angled surface of the non-deformed tines **250** can generally match the taper of the tapered portion **308**.

In some embodiments, when the bore **212** in the crimpless contact **200** is circumferentially and longitudinally aligned with a pin slot **314** of the outer housing **300**, the anti-rotation pin **500** can be inserted through the pin slot **314** and into the bore **312**. In the example shown in FIGS. **1A-1C**, the outer housing **300** comprises two circumferentially and longitudinally aligned pin slots **314**. The anti-rotation pin **500** can be inserted through the crimpless contact **200** such that the anti-rotation pin **500** extends through both pin slots **314**. The anti-rotation pin **500** can be a length sufficient to extend through a diameter of the crimpless contact **200** and into both pin slots **314**. The length can be configured not to expand the cross-sectional profile of the crimpless connector **100**, which can be advantageous for inserting (e.g., slidably inserting) the crimpless contact **100** in an external channel, such as the channel of a dielectric insulator. In some embodiments, the bore **212** in the crimpless contact **200** can terminate in the interior portion **206** of the crimpless contact **200** and/or the outer housing **300** can comprise only one pin slot **314**. During assembly of the anti-rotation pin **500** with the crimpless contact **200** and the outer housing **300**, the anti-rotation pin **500** can inhibit or prevent rotation in either a first or second direction (clockwise or counterclockwise) around the longitudinal axis of the crimpless contact **200** and the outer housing **300** relative to one another.

The contact facilitator **400** can be received in the distal channel **205** of the crimpless contact **200**. The contact facilitator **400** can be configured to be compressed radially inward so that it can be received through the distal end of the distal channel **205** of the crimpless contact **200**. The contact facilitator **400** can be compressed by applying pressure to the circumference of the proximal ring-like portion **403** and/or the distal ring-like portion **405** to temporarily decrease the outer diameter of the contact facilitator **400** by decreasing the width of the gaps **406** in the outer circumference of the ring like portions **403**, **405**. The compressed outer diameter of the deformed contact facilitator **400** can be configured to be slightly less than the diameter of the distal channel **205** at the distal end-face of the crimpless contact **200**. The proximal ring-like portion **403** and the distal ring-like portion **405** can be compressed (e.g., by the assembler) simultaneously or just prior to the insertion of each ring like portion **403**, **405** into the distal channel **205**. The contact facilitator **400** can be pushed proximally into the distal channel **205** until it comes to sit in the expanded diameter portion **208** of the distal channel **205**. In the expanded diameter portion **208**, the contact facilitator **400** may or may not remain at least partially compressed. The outer diameter of the contact facilitator **400** can be configured to contact the elongate body **201** of the crimpless contact **200** along the length of the partially expanded portion **208** to establish an electrical connection.

The distal end **204** of the crimpless contact **200** can be received in the proximal end **602** of the activation nut **600**. The activation nut **600** can be coupled to the distal end **204** of the crimpless contact **200** by slidably inserting the distal end **204** of the crimpless contact **200** into the channel **606** until the threaded portion **210** of the elongate body **201** of the crimpless contact **200** encounters the threaded portion **608** of the channel **606** of the activation nut **600**. The activation nut **600** can then be rotated in a second direction (e.g., clockwise or counterclockwise) to engage the threads of the threaded portion **210** and threaded portion **608**. As shown in FIG. **1**B, the activation nut **600** can be threaded onto the distal end **204** of the crimpless contact **200** until the distal end **204** of the crimpless contact **200** abuts the proximal side of the distal closed end-face **605** and/or until the proximal end **602** of the activation nut **600** abuts the distal end **304** of the outer housing **300**. In some embodiments, this puts the crimpless connector **100** in the first configuration. In the first configuration of the crimpless connector **100**, the axial separation along the longitudinal axis between the distal end **204** of the crimpless contact **200** and the proximal side of the face **605** of the activation nut **600** can be at a minimum.

The first conductor C**1** can be inserted into the proximal end **102** of the crimpless connector **100**. A free end of the first conductor C**1** can be received through the open end-face of the proximal end **302** of the outer housing **300** and by the proximal channel **203** of the crimpless contact **200**. The first conductor C**1** can be inserted so that the free end abuts the end of the proximal channel **203**. The first conductor C**1** can be inserted after assembly of the crimpless contact **200** and outer housing **300** or after assembly of the entire crimpless connector **100**. The crimpless connector **100** can be configured to receive the first conductor C**1** when in the first configuration (e.g., a non-deformed configuration) and/or to physically secure the first conductor C**1**, inhibiting and/or preventing pull-out, in the second configuration (e.g., a deformed configuration). In several embodiments, connector **100** is configured such that the securement (e.g., clamping force) of the first conductor C**1** in the connector **100** increases in response to a pulling force on the first conductor C**1**.

The crimpless connector **100** can be transitioned between the first configuration and the second configuration by rotation of the activation nut **600** about the longitudinal axis. Rotation in a first direction (clockwise or counterclockwise) can transition the crimpless connector **100** from the first configuration to the second configuration, while rotation in a second, opposite direction can transition the crimpless connector **100** from the second configuration to the first configuration. The activation nut **600** can be rotated by applying a torque in a first or second direction to the activation nut **600** via an activation tool (e.g., an Allen key) inserted in the aperture **607** of the activation nut **600**. In some embodiments, the assembler can apply a torque to the outer circumference of the activation nut **600** (e.g., by manually turning the activation nut **600**). The crimpless contact **200** can be prevented from rotating in the same direction as the activation nut **600** by the anti-rotation pin **500**. The anti-rotation pin **500** can be prevented from rotating in the same direction as the activation nut **600** by the outer housing **200**. The outer housing **200** can be prevented by rotating in the same direction as the activation nut **600** by an externally applied force. The external force can be applied manually by the assembler or can be applied by an externally coupled structure, such as a dielectric insulator. For example, if the threaded portion **312** of the outer housing **300** is engaged with a threaded lumen in a fixated external structure, the external structure can prevent rotation of the outer housing **200**.

As mentioned above, the threaded portion **608** of the activation nut **600** and the complementary threaded portion **210** of the crimpless contact **200** can be configured in a first orientation and the threaded portion **312** of the outer housing **300** and a complementary threaded lumen of an external structure can be configured in a second orientation, opposite the first orientation. In some embodiments, rotation of the activation nut **600** in a first rotational direction unthreads a portion of the crimpless contact **200** out of threaded engagement with the activation nut **600**, thereby translating the crimpless contact **200**, as can be seen from FIGS. **1**B and **1**C. In some embodiments, rotation in the first direction of the activation nut **600** further tightens the threaded engagement between the threaded portion **312** of the outer housing **300** and the external structure.

In certain variants, rotation of the activation nut **600** in a first direction can increase the separation distance between the face **605** of the activation nut **600** and the distal end **204** of the crimpless contact **200**, while rotation of the outer housing **200** in the first direction can decrease the separation distance between the outer housing **300** and an external structure. If the separation distance between the outer housing **300** and external structure is incapable of being decreased, the two components can be incapable of rotating relative to one another. For instance, if the shoulder **313** of the outer housing **300** is abutting a corresponding shoulder of the fixated external structure (e.g., the outer housing **300** cannot move further in the proximal direction), the outer housing **300** can be inhibited or prevented from rotating in the first direction around the longitudinal axis. Frictional resistance between the elongate body **301** of the outer housing **300** and a corresponding channel of an external structure can also inhibit rotation of the outer housing **300**.

In some embodiments, an external structure can be assembled around the crimpless connector **100**, confining it to a channel of a fixed length. The fixed length of the channel in the external structure can inhibit or prevent the axial separation of the outer housing **300** if engaged with a threaded lumen of the external structure, even if the threads of the outer housing **300**, external structure, crimpless contact **200**, and activation nut **600** all are configured with the same orientation (right handed or left handed). The outer housing **300** can rotationally fix the anti-rotation pin **500**, preventing it from rotating around the longitudinal axis. The anti-rotation pin **500** can inhibit or prevent the crimpless contact **200** from rotating around the longitudinal axis. In certain embodiments, the connector **100** has a substantially constant longitudinal length. For example, as can be seen in FIGS. **1**B and **1**C, the longitudinal length in the first configuration can be substantially equal to the longitudinal length in the second configuration. In some variants, the connector **100** has a variable longitudinal length.

In various embodiments, rotation of the activation nut **600** results in translation of the crimpless contact **200** relative to the activation nut **600** and/or the outer housing **300**. For example, in some implementations, when the crimpless contact **200** is fixed so that it cannot rotate in the first direction, rotation of the activation nut **600** in the first direction can force an increase in the separation distance between the activation nut **600** and the crimpless contact **200**.

If movement of the activation nut **600** in the distal direction is prohibited or inhibited (e.g., by the external structure E or a manually applied force in the distal direction during rotation), the crimpless contact **200** will be induced to translate in the proximal direction. In some embodiments, an external structure can be assembled around the crimpless connector **100**. The external structure can include a neck portion that allows the activation tool to access the activation nut **600** which inhibits or prevents movement of the activation nut **600** in a distal direction.

Various embodiments provide movement of the crimpless contact **200** in a proximal direction during rotation of the activation nut **600** in the first direction. If the outer housing

300 is axially fixed along the longitudinal axis (e.g., by an external structure abutting should 313), the proximal end 202 of the crimpless contact 200 will be forced further inside the lumen 306 of the outer housing 300 by a distance equivalent to the change in distance between the face 605 of the activation nut 600 and the distal end 204 of the crimpless contact 200.

In various embodiments, the crimpless contact 200 can be engaged with the tapered portion 308 of the lumen 306 of the outer housing 300. For example, during rotation of the activation nut 600 in the first direction, the tines 250 of the crimpless contact 200 can be forced against the tapered portion 308 of the lumen 306 of the outer housing 300. The tines 250 can be compressed radially inward by the decreasing diameter of the tapered portion 308. The compression of the tines 250 can force the tines 250 around the circumference of the first conductor C1. In some embodiments, the tines 250 apply substantially uniform pressure around the circumference of the first conductor C1. The textured surface 258 can facilitate the grip of the tines 250 on the first conductor C1 along a length of the tines 250. The pressure applied by the tines 250 in the second configuration and/or in intermediate configurations between the first and second configurations can apply a counterforce to a retraction force on the first conductor C1, which helps the first conductor C1 resist pull-out. The pressure applied by the tines 250 can ensure a good electrical connection between the first conductor C1 and the crimpless contact 200.

In various embodiments, the crimpless connector 100 is configured to avoid or reduce pulling or retracting the first conductor C1 into the outer housing 300 and/or crimpless contact 200 during assembly and/or operation. This can reduce strain on the first conductor C1 and/or can reduce the likelihood of the first conductor C1 becoming disconnected at another location (e.g., at another end of the first conductor C1). In some implementations, the crimpless connector 100 pushes a portion of the first conductor C1 out of the crimpless connector 100 in transitioning from the first to the second configuration. In some embodiments, as the tines 250 are being radially compressed and/or during rotation of the activation nut 600 in a first direction, a portion of the first conductor C1 is moved axially a distance out of the connector 100.

As the crimpless contact 200 transitions between the first configuration and second configuration, the anti-rotation pin 500 can slide along the length of the pin slots 314 from the distal ends of the pin slots 314 to the proximal ends of the pin slots 314. The proximal ends of the pin slots 314 can limit the amount of translation of the crimpless contact 200 and can inhibit the activation nut 600 from rotating when the second configuration is achieved. Some embodiments of the crimpless connector 100 do not comprise an activation nut 600. In certain embodiments, the crimpless contact 200 can be inserted or retracted from the outer housing 300 by the direct manual application of a force in the proximal or distal direction, respectively.

In some embodiments, the second conductor C2 is inserted into the crimpless connector 100. In some embodiments, this occurs after securing the first conductor C1 and/or after the activation tool has been removed from the aperture 607 of the activation nut 600. A free end of the second conductor C2 can be received through the aperture 607 of the activation nut 600 and by the distal channel 205 of the crimpless contact 200. The second conductor C2 can be inserted so that the free end abuts the end of the distal channel 205. Upon insertion of the second conductor C2, the outer diameter of the second conductor C2 can be greater than the inner diameter of the contact facilitator 400 in a non-deformed or partially deformed state. The second conductor C2 can press against the struts 408 of the contact facilitator 400 forcing the inner diameter of the contact facilitator 400 to expand as the struts 408 are forced to partially straighten, reducing the curvature of the struts 408. As the struts 408 are pressed outward, the length of the contact facilitator 400 can increase as the proximal and distal ring-like portions 403, 405 are forced further apart. The length of the expanded portion 208 of the distal channel 205 can limit the expansion of the contact facilitator 400. In some embodiments, the struts 408 of the contact facilitator can continue to be deformed even after the contact facilitator 400 has expanded to the full length of the expanded portion 208 of the distal channel 205.

After insertion of the second conductor C2, the struts 408 can apply physical pressure to the outer circumference of the second conductor C2, thereby facilitating a good electrical connection between the second conductor C2 and the contact facilitator 400. The contact facilitator 400 can be pressed into the expanded portion 208 of the distal channel 205 of the crimpless contact 200 by the second conductor C2 and/or the contact facilitator 400 can exert a counterforce on the crimpless contact 200 if the expanded portion 208 of the distal channel 205 of the crimpless contact 200 is configured to compress the contact facilitator 400 into at least a partially deformed state. The pressure exerted by the contact facilitator 400 on the crimpless contact 200 can facilitate a good electrical connection between the contact facilitator 400 and the crimpless contact 200. The crimpless contact 200 can establish an electrical connection between the first conductor C1 and the second conductor C2 in the second configuration. In some embodiments, the crimpless contact 200 establishes an electrical connection between the first and second conductors C1, C2 in the first configuration and/or intermediate configurations.

Upon removal of the second conductor C2, rotation of the activation nut 600 can transition the crimpless connector from the second configuration to the first configuration, facilitating the removal of the first conductor C1 from the proximal end 202 of the crimpless contact 200. The crimpless connector 100 can easily be disassembled as needed by reversing the steps employed to assemble each component to another component. The crimpless connector 100 can be reusable and can be repeatedly assembled and disassembled as needed. The first and second conductors C1, C2 can also be reused upon removal from the crimpless connector 100.

Certain Terminology

Although connectors have been disclosed in the context of certain embodiments and examples, it will be understood by those skilled in the art that the connectors extend beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the embodiments and certain modifications and equivalents thereof. Use with any structure is expressly within the scope of this invention. Various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the assembly. The scope of this disclosure should not be limited by the particular disclosed embodiments described herein.

Certain features that are described in this disclosure in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable subcombination. Moreover, although features can be described above as acting in certain combinations, one or more features from a claimed combination can, in some cases, be excised from the combination, and the combination can be claimed as any subcombination or variation of any subcombination.

Terms of orientation used herein, such as "top," "bottom," "proximal," "distal," "longitudinal," "lateral," and "end" are used in the context of the illustrated embodiment. However, the present disclosure should not be limited to the illustrated orientation. Indeed, other orientations are possible and are within the scope of this disclosure. Terms relating to circular shapes as used herein, such as diameter or radius, should be understood not to require perfect circular structures, but rather should be applied to any suitable structure with a cross-sectional region that can be measured from side-to-side. Terms relating to shapes generally, such as "circular" or "cylindrical" or "semi-circular" or "semi-cylindrical" or any related or similar terms, are not required to conform strictly to the mathematical definitions of circles or cylinders or other structures, but can encompass structures that are reasonably close approximations.

Conditional language, such as "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include or do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more embodiments.

Conjunctive language, such as the phrase "at least one of X, Y, and Z," unless specifically stated otherwise, is otherwise understood with the context as used in general to convey that an item, term, etc. can be either X, Y, or Z. Thus, such conjunctive language is not generally intended to imply that certain embodiments require the presence of at least one of X, at least one of Y, and at least one of Z.

The terms "approximately," "about," and "substantially" as used herein represent an amount close to the stated amount that still performs a desired function or achieves a desired result. For example, in some embodiments, as the context can dictate, the terms "approximately", "about", and "substantially" can refer to an amount that is within less than or equal to 10% of the stated amount. The term "generally" as used herein represents a value, amount, or characteristic that predominantly includes or tends toward a particular value, amount, or characteristic. As an example, in certain embodiments, as the context can dictate, the term "generally parallel" can refer to something that departs from exactly parallel by less than or equal to 20 degrees.

Some embodiments have been described in connection with the accompanying drawings. The figures are to scale, but such scale should not be limiting, since dimensions and proportions other than what are shown are contemplated and are within the scope of the disclosed invention. Distances, angles, etc. are merely illustrative and do not necessarily bear an exact relationship to actual dimensions and layout of the devices illustrated. Components can be added, removed, and/or rearranged. Further, the disclosure herein of any particular feature, aspect, method, property, characteristic, quality, attribute, element, or the like in connection with various embodiments can be used in all other embodiments set forth herein. Additionally, it will be recognized that any methods described herein can be practiced using any device suitable for performing the recited steps.

SUMMARY

In summary, various embodiments and examples of connectors have been disclosed. Although the connectors have been disclosed in the context of those embodiments and examples, this disclosure extends beyond the specifically disclosed embodiments to other alternative embodiments and/or other uses of the embodiments, as well as to certain modifications and equivalents thereof. This disclosure expressly contemplates that various features and aspects of the disclosed embodiments can be combined with, or substituted for, one another. Accordingly, the scope of this disclosure should not be limited by the particular disclosed embodiments described above, but should be determined only by a fair reading of the claims that follow.

The invention claimed is:

1. An electrical connector assembly for connecting a first conductor and a second conductor, the connector assembly comprising:

- a housing comprising a lumen and an inner surface, the inner surface comprising a tapered portion having a first diameter at a proximal end and a second diameter at a distal end, the first diameter being less than the second diameter, the housing being configured to connect with an external dielectric structure;
- a contact configured to conduct electricity, the contact comprising:
  - a proximal end that is received in the housing, the proximal end comprising a plurality of elastically deformable tines, the tines bounding a passage that is configured to receive the first conductor; and
  - a distal end comprising a threaded outer surface and a distal channel, the distal channel configured to receive the second conductor;
- an anti-rotation feature configured to inhibit relative rotation of the contact and the housing; and
- an activation nut comprising:
  - a threaded inner surface that is engaged with the threaded outer surface of the distal end of the contact; and
  - an aperture on a distal end of the activation nut, the aperture configured to enable the second conductor to be passed through the aperture of the activation nut and into the distal channel of the contact;
- the electrical connector assembly configured such that:
  - in response to rotation of the activation nut in a first rotational direction, the contact translates relative to the housing in a first longitudinal direction which causes the tines to slide down the taper of the housing, thereby radially compressing the tines around the first conductor; and
  - in response to rotation of the activation nut in a second rotational direction, the contact translates relative to the housing in a second longitudinal direction which causes the tines to slide up the taper of the housing, thereby radially expanding the tines away from the first conductor.

2. The electrical connector assembly of claim **1**, wherein the anti-rotation feature comprises a pin.

3. The electrical connector assembly of claim **1**, wherein the activation nut aperture is further configured to receive a tool, wherein the activation nut is configured to be rotated by the tool.

4. The electrical connector assembly of claim **1**, wherein the electrical connector assembly comprises a first configuration and a second configuration, the tines of the contact being substantially non-deformed in the first configuration and the tines being compressed radially inward by the tapered portion of the housing lumen in the second configuration.

5. The electrical connector assembly of claim 1, wherein:
the housing further comprises an elongate slot that receives the anti-rotation feature; and
the anti-rotation feature translates in the elongate slot as the contact translates relative to the housing.

6. The electrical connector assembly of claim 1, wherein the electrical connector is further configured such that the radial compression of the tines against the first conductor pushes a portion of the first conductor out of the contact.

7. The electrical connector assembly of claim 1, wherein at least one of the tines comprises a groove, the at least one of the tines being designed to bend at the groove during engagement with the tapered portion of the housing.

8. The electrical connector assembly of claim 1, wherein at least one of the tines comprises teeth for gripping the first conductor.

9. The electrical connector assembly of claim 1, wherein the proximal end of the housing comprises a threaded outer surface.

10. The electrical connector assembly of claim 9, wherein the threaded outer surface of the contact is threaded in a first direction and the threaded outer surface of the housing is threaded in a second direction, opposite the first direction.

11. An electrical connector assembly for connecting a first conductor and a second conductor, the electrical connector assembly comprising:
a contact configured to receive the first conductor and the second conductor, the contact comprising a plurality of tines bounding a passage;
a housing that receives a portion of the contact and that is configured to connect with an external structure, the housing comprising a conduit with a taper; and
an activation unit engaged with the contact, the activation unit configured to rotate relative to the contact, the connector assembly configured such that rotation of the activation unit relative to the contact transitions the contact between a first configuration and a second configuration;
wherein, in the first configuration, the contact is positioned in a first axial position relative to the housing and the tines are in a first radial position such that the first conductor can be inserted into the passage; and
wherein, in the second configuration, the contact is positioned in a second axial position relative to the housing and the tines are in a second radial position such that the tines grip the first conductor in the passage, thereby securing the first conductor from pull-out.

12. The electrical connector assembly of claim 11, wherein, during the transition between the first and second configurations, the contact slides within the housing.

13. The electrical connector assembly of claim 11, further comprising an anti-rotation pin configured to inhibit relative rotation of the contact and the housing, the connector assembly further configured such that the anti-rotation pin slides in a longitudinal slot of the housing during the transition between the first configuration and the second configuration.

14. The electrical connector assembly of claim 11, wherein the connector assembly has a longitudinal length in the first configuration that is substantially equal to the longitudinal length in the second configuration.

15. A method of using a crimpless electrical connector assembly to establish an electrical connection between a first conductor and a second conductor, the electrical connector assembly comprising a contact, an outer housing configured to connect with an external structure, and an activation unit, the method comprising:
inserting the first conductor into a proximal end of the contact, a portion of the contact comprising tines that are configured to be elastically deformed around the first conductor, the contact being electrically conductive;
engaging a tool with the activation unit;
moving, using the tool, the activation unit in a first direction relative to the contact;
sliding the tines of the contact along a tapered surface of the outer housing;
radially compressing the tines against the first conductor, thereby gripping the first conductor in the contact; and
inserting the second conductor through an aperture in the activation unit and into a distal end of the contact.

16. The method of claim 15, wherein engaging the tool with the activation unit comprises inserting the tool into the aperture of the activation unit.

17. The method of claim 15, wherein moving the activation unit relative to the contact comprises rotating the activation unit relative to the contact around a longitudinal axis.

18. The method of claim 15, wherein the method further comprises engaging threads on an outer surface of the housing with threads of an external insulating structure.

19. The method of claim 15, wherein sliding the tines of the contact along the tapered surface of an outer housing comprises disengaging a portion of threads of the contact from a portion of threads of the activation unit.

20. The method of claim 15, further comprising maintaining, with an anti-rotation feature, the contact and the housing in a rotational position relative to each other.

21. The method of claim 20, further comprising sliding the anti-rotation feature along a slot in the outer housing.

22. A method comprising:
establishing, with method of claim 15, the electrical connection between the first conductor and the second conductor; and
disconnecting the electrical connection between the first conductor and the second conductor, wherein disconnecting the electrical connection comprises:
moving, using the tool, the activation unit in a second direction relative to the contact, the second direction generally opposite the first direction;
radially expanding the tines away from the first conductor, thereby releasing the first conductor from the grip of the contact; and
removing the first conductor from the contact.

23. The method of claim 22, wherein moving the activation unit relative to the contact comprises rotating the activation unit relative to the contact around a longitudinal axis.

24. The method of claim 22, further comprising sliding the contact toward the aperture in the activation unit.

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